Fiscal stimulus in a small euro area economy*

Vanda Almeida Gabriela Castro Ricardo Mourinho Félix
José Francisco Maria
Economics and Research Department, Banco de Portugal†

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Abstract

The international economic and financial crisis elicited an intensive debate on fiscal stimulus programmes. Although the topics have been diverse, most of the research is focused on large countries, some of them in autarky. The literature covering small economies is thinner and for those integrated in a monetary union is virtually non-existent. This paper is a contribution to fill this gap. The discussion draws on a New-Keynesian general equilibrium model introduced in Almeida, Castro and Félix (2008), which features a small euro area economy. Contrary to most of the literature that considers infinitely lived households, the model features stochastic finite lifetime households following Blanchard (1985), which are a source of non-Ricardian behaviour and allow for pinning-down the steady state net foreign asset position endogenously. Since in a small euro area economy monetary policy is not an available business cycle stabilisation tool, the use of fiscal policy to pursue this goal seems the only alternative. The results reveal that permanent government expenditure increases should be avoided, as opposed to temporary stimulus. This outcome is identical to the one obtained in the literature for large economies. Lags in the program implementation and limited credibility can however undermine the objectives of a temporary stimulus. In particular, in financial distress circumstances, under which the stimulus may trigger a hike in the country's risk premium, the effectiveness of the stimulus might be negligible.

Keywords: fiscal stimulus; fiscal multiplier; DSGE model; small-open economy.
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†Address for correspondence: Banco de Portugal, Departamento de Estudos Económicos, Rua Francisco Ribeiro, 2, 1150-165 Lisboa. E-mails: vralmeida@bportugal.pt, ggcastro@bportugal.pt, rfelix@bportugal.pt and jfrmaria@bportugal.pt.

1 Introduction

The international economic and financial crisis elicited an intensive debate and research on the impact of fiscal stimulus programmes. The analysis using general equilibrium models was wide open, and included the assessment of temporary vs. permanent fiscal stimulus, the key role of private demand (in particular the response of households consumption), the implications of standard monetary policy reactions vs. the binding zero lower bound, the assessment of alternative fiscal policy instruments, the analysis of both supply and demand-side impacts and credibility issues, among others. Without completeness, relevant studies include Christiano, Eichenbaum and Rebelo (2009), Eggertsson (2009), Freedman, Kumhof, Laxton and Lee (2009), Hall (2009), Kumhof, Muir, Freedman, Mursula and Laxton (2009), Cogan, Cwik, Taylor and Wieland (2009), and Erceg and Lindé (2010). The relative performance of seven structural models is presented in Coenen, Erceg, Freedman, Furceci, Kumhof, Lalonde, Laxton, Lindé, Mourougane, Muir, Mursula, de Resende, Roberts, Röeger, Snudden, Trabandt and in't Veld (2010).

So far the debate seems to have been focused primarily in large economies with independent monetary policy reaction functions guided by Taylor-type rules, some of them operating in autarky. The literature becomes thinner if one moves into the small open economy (henceforth SOE) environment, and is virtually non-existent in the case of economies integrated in monetary unions. An exception can be found in Kumhof and Laxton (2009), in which the impact of a fiscal stimulus on the current account was discussed for both the SOE and large economy cases. It is well known that in a SOE operating in a complete markets framework, households and the government can buy insurance against all states of nature without affecting world prices of contingent claims and that in this case optimal fiscal policy corresponds to a fully-fledged tax smoothing (Goodfriend and King 2001). However, this is hardly the case for many small euro area economies, in which the access to world markets is intermediated by a few domestic banks and, therefore, country risk is highly concentrated, which may lead to risk discrimination in international markets, thereby invalidating the complete markets assumption.

This article widens the fiscal stimulus discussion by focusing on a SOE integrated in the euro area and represents a contribution to fill the aforementioned gap in the debate over fiscal stimulus programmes. The discussion is based on *PESSOA*, a New-Keynesian overlapping generations model introduced in Almeida et al. (2008), whose structure draws on several contributions, notably Kumhof and Laxton (2007*a*). The general equilibrium model was designed and calibrated to fit the characteristics of a SOE integrated in a monetary union, under the assumption that international trade in goods and assets is only performed with the rest of the union. The economy is assumed to be small enough to have negligible impact in the union aggregates and ultimately in monetary authority decisions. Therefore, all foreign variables, namely foreign interest rates, output and prices, are assumed to be exogenous, as in Adolfson, Laseén, Lindé and Villani (2007). Hence, nominal stability is ensured by the full credibility of the inflation objective set by the monetary authority. In addition, the dynamic stability stems from large elasticities of real trade variables to real exchange rate fluctuations. In the presence of a shock (be it a real or a relative price shock), the adjustment to the long-run equilibrium requires adjustments in domestic real variables and relative prices. The model operates *de facto* like a real model (similarly to a fully credible fixed nominal exchange rate model), since domestic price levels are pinned down by the external constraint that sets a unique steady-state real exchange rate. 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. Also noteworthy is the existence of a foreign risk premium that allows for the existence of a spread between domestic and foreign interest rate.

Contrary to most DSGE models in the literature on SOE, PESSOA is intrinsically non-Ricardian, featuring stochastic finite lifetime households (Blanchard 1985, Yaari 1965), distortionary taxation and a share of liquidity constrained households (Galí, López-Salido and Vallés 2007). These, coupled with a rich fiscal block, make the model particularly suited to analyse fiscal policy issues. In particular, the stochastic 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 workhorse infinitely lived agents model. In addition, the Blanchard-Yaari framework allows for the endogenous determination of the net foreign asset position (Harrison, Nikolov, Quinn, Ramsay, Scott and Thomas 2005), thereby delivering a more 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 outcome of a fiscal stimulus in a SOE operating in a monetary union depends upon several factors. Fiscal policy management has operational limits not only due to the need of ensuring a sustainable public debt path, but also by possible institutional limits, which in the case of the euro area are imposed by the Stability and Growth Pact. Other conditioning factors are the degree of credibility of the domestic fiscal authorities and the nature of the fiscal stimulus. This article shows that while temporary boosts under full credibility may be used to achieve macroeconomic stabilisation goals, the permanent case should be avoided, a result similar to the one encountered for large economies (Cogan et al. 2009, Freedman, Kumhof, Laxton and Lee 2009, Coenen et al. 2010). The fiscal stimulus outcome in a SOE is also conditioned by a timely implementation of the programme, a result also highlighted in the literature (Erceg and Lindé 2010). Finally, this article also claims that when a temporary fiscal policy is not conducted under full credibility, either because the stimulus is perceived as being permanent, at least initially, or because the economy may face an higher risk premium, which may be conditioned by the initial public debt levels, then the macroeconomic stabilisation goals may be hindered. If the implementation of a fiscal stimulus programme triggers a sharp increase in the risk premium, it may partially backfire the intentions behind the programme.

The paper is organized as follows. The model is presented in section 2. A special focus is placed on the fiscal block and on its non-Ricardian features. Section 3 evaluates the impact of five temporary fiscal measures under full credibility and timely implementation: (i) an increase in government consumption; (ii) an increase in general transfers (transfers to all households); (iii) an increase in targeted transfers (transfers to liquidity-constrained households); (iv) a decrease in labour income tax; and (v) a decrease in private consumption tax. Section 3 also evaluates the impact of implementation lags and of a permanent stimulus. Section 4 uses the model to analyse the impact of a fiscal stimulus under limited credibility, and section 5 concludes.

2 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 impact of the fiscal stimulus. The model was introduced and calibrated for Portugal in Almeida et al. (2008) and used to analyse shocks that hit the Portuguese economy over the last decade in Almeida, Castro and Félix (2009). It can however be easily re-calibrated to fit the characteristics of any other small euro area economy. The model has intrinsic non-Ricardian features largely inspired in the IMF's Global Integrated Monetary and Fiscal model presented in Kumhof and Laxton (2007*a*). The current setup was enhanced to allow for richer fiscal policy simulations. The SOE structure implies assuming that the rest of the monetary union is not affected by domestic shocks. This is tantamount to say that union aggregates and, therefore, monetary policy decisions are orthogonal to developments in the SOE, as in Adolfson et al. (2007).

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). Contrary to most DSGE models in the literature on SOE, PESSOA is intrinsically non-Ricardian, featuring: finitely-lived households in line with the stochastic lifetime framework proposed by Blanchard (1985) and Yaari (1965); distortionary taxation on households consumption, labour and capital income; and liquidity constrained households as in Galí et al. (2007). The fiscal block of the model is rich 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), the finitely lived agents framework implies that households discount future events at a higher rate than the Government (the so-called over-discounting behaviour). This creates sizeable wealth effects of public debt, which are absent in the workhorse infinitely-lived agent framework. In particular, households strongly prefer debt issuance to tax financing of Government expenditure, since they attach a positive probability to the fact that they might not be around in the future when taxes required to meet debt issued today are levied. It should be mentioned that technically it is not the event that current generations will die that generates the non-Ricardian effect, but rather the fact that future generations will bear some of the tax burden (Buiter 1988). In addition, the

Blanchard-Yaari framework allows for the endogenous determination of the net foreign asset position (Harrison et al. 2005), since in a finite lifetime the amount of assets/debt that a household can accumulate is inevitably limited by life expectancy.[1] 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.

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 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 that is assumed to be exogenous. This implies that domestic shocks affecting domestic inflation developments tend to generate powerful effects on the real interest rate, amplifying the fluctuations of the economy. 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 only trade in goods and assets/debt 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. This position is pinned down in the steady state by the foreign asset/debt level constraint and its impact in households financial wealth (and, ultimately, in consumption). Since foreign prices developments are assumed to be independent of domestic shocks, the real exchange rate pins down uniquely the domestic price level.

PESSOA features a number of nominal and real rigidities and frictions that give rise to realistic short-run impulse functions. On the nominal side, there is differentiation in the labour and product markets, allowing for monopolistic competition and staggered wage and price inflation. On the real side, the model incorporates external habit formation, and adjustment costs on investment and import contents.

The model is populated by households, which will be presented in detail in subsection 2.1, unions, presented in subsection 2.2, and firms (intermediate goods producers and final goods producers), which will be presented in subsection 2.3. All these agents interact with a Government, which is described in subsection 2.4. The rest of the world, corresponding to the rest of the monetary union, is presented in subsection 2.5, while the market clearing conditions are presented in section 2.6. The model is calibrated, as detailed in subsection

[1] 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).

2.7.

2.1 Households

Households evolve in line with the overlapping generations scheme first proposed in Blanchard (1985). All of them have a finite lifetime, facing an instant probability of death $1-\theta$ in each period (θ is the probability of surviving between two consecutive periods), which is constant throughout life, independent of age, and equal for all households.[2] However, the 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/debt markets and perform both intra and inter-temporal optimisation, smoothing out their consumption over lifetime by trading assets; and type $\mathcal{B}$, the liquidity constrained households that do not access asset/debt 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 $N\psi$ liquidity constrained 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 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.[3]

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, it 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 respective productivity, $\Phi_a = k\chi^a$, where k is a scaling

[2]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 taken as a probability of "economic death" or the 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 whole lifetime. Bayoumi and Sgherri (2006) present econometric evidence for the US.

[3]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.

factor and $0 \leq \chi \leq 1$ the labour productivity rate of decay per period that mimics life-cycle profile. Furthermore, they receive dividends from firms and from labour unions (representing a wage premia that will be motivated later on). These are represented by $D^{\mathcal{A}}_{a,t}(x)$ where x can be: intermediate goods producer of tradable ($\mathcal{T}$) and non-tradable goods ($\mathcal{N}$), final goods producer of private consumption ($\mathcal{C}$), government consumption ($\mathcal{G}$), capital ($\mathcal{I}$), or export goods ($\mathcal{X}$), and labour unions ($\mathcal{U}$). Finally, they 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 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 financing government expenditure with current tax levies or with 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, a finite lifetime household will hold part of this debt, but may not be around at the time taxes are levied, implying that part of the debt can be used to finance private consumption expenditures during lifetime, instead of being used to face future taxes payments. These effects are magnified by the fact that the labour income tax represents an important part of all tax revenues. The life-cycle profile implies that even if a household is alive at the time taxes are levied, it can be at very low productivity and wage levels, which reduces its tax payments. Finite lifetime and life-cycle income profile create myopic and relatively more short-term oriented households, as they over-discount future events.

For type $\mathcal{B}$ households, the lack of access to assets/debt market implies that the inter-temporal optimisation problem collapses to an intra-temporal optimisation problem (due to the impossibility of shifting consumption across periods). These households cannot save, merely choosing consumption and labour that maximise their instant period-by-period utility introducing an additional layer of non-Ricardian behavior that is crucial to obtain realistic impact 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 liquidity constrained 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 households that yields their optimal consumption-leisure decision, the consumption function, which depends on wealth in the case of asset holders and on per-period income in the case of liquidity constrained households and a degenerated interest rate parity condition that defines the equilibrium in the bonds market and that essentially implies that domestic interest rates deviate from foreign interest rates by the exogenous risk premium, Ψ (in short, $i_t = i^*_t \Psi$).

2.2 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 are willing to 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.

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, $\Gamma^{\mathcal{U}}_t(h)$. In the spirit of Kim (2000), Ireland (2001) and Laxton and Pesenti (2003), the following quadratic adjustment costs are used:

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

where $\phi_{\mathcal{U}}$ is the adjustment cost parameter and T_t 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:

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

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 $r = i_t/(P_t/P_{t+1})$ is the real interest rate. Period t dividends, $D^{\mathcal{U}}_t(h)$, are defined as:

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

It should be noted that households are usually the ones who 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), 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 Kumhof and Laxton (2007*a*), while wage stickiness is modeled as (5).

2.3 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 is obtained through the accumulation of investment goods bought from distributors. The intermediate goods are then sold to distributors, who combine them with imports from the rest of the world to produce a differentiated final good variety. There are four types of final goods: consumer goods ($\mathcal{C}$); capital goods ($\mathcal{I}$); government consumption goods ($\mathcal{G}$) and export goods ($\mathcal{X}$), which differ in its content of tradables, non-tradables and imports.

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 different variety of the good, $Z^J_t(j)$, using capital, $K^J_t(j)$, and labour, $U^J_t(j)$, as inputs. It sell its good at price $P^J_t(j)$, which is higher than their marginal cost, reflecting the market power generated by product differentiation.

The production technology is modelled using the following CES function:

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

where $0 \leq \xi_{ZJ} \leq \infty$ is the elasticity of substitution between capital and labour in the type J sector; $0 \leq \alpha_U^J \leq 1$ is the quasi-labour share; A_t^J is a stationary sector-specific technology shock; 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 law of motion:

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

where $0 \leq \delta^J \leq 1$ is a sector-specific 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 how costly is to change investment and labour services for firms in sector J; 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 intermediate good of sector J, which is sold to distributors at price P_t^J.

Each distributor demands a certain quantity of all varieties included in the bundle Z_t^J, 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 good 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 law of motion, adjustment costs and demand condition. 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 *Operational cashflow*$_t$ is defined as the difference between overall revenue and expenditure, as follows:

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

with $P_t^J(j) Z_t^J(j)$ corresponding to overall revenue, $(1+\tau_{SP}) V_t U_t^J(j)$ being labour costs inclusive of employer social security contributions (τ_{SP} is presented below in subsection 2.4), and $P_t^{\mathcal{I}} I_t^J(j)$ standing for investment spending, where $P_t^{\mathcal{I}}$ is the price of investment 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 used quantities of labour and capital. 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.[4]

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

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

where q_t^J is the shadow price of a unit of installed capital in terms of current investment goods (Tobin's-Q).

Distributors

For each type of final good $F \in \{\mathcal{C}, \mathcal{G}, \mathcal{I}, \mathcal{X}\}$ there is a continuum of distributing firms $f \in [0,1]$. Each type 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 also incorporates a markup over the marginal cost of production.

[4] 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 good, $Z_t^{\mathcal{N}F}(f)$, to produce variety f of the final good $Y_t^F(f)$, which is then sold to final costumers. The production technology is formalised as a sector specific nested CES technology.

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

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

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 variety f import content $M_t^F(f)/Y_t^{\mathcal{A}F}(f)$, given by:

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

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 for variety f of the final good of type F is defined as:

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

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

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

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

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

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

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

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 production technology, adjustment costs and demand conditions. Period t dividends, $D_t^F(j)$, are defined as:

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

which corresponds to the after-tax difference between total revenue $P_t^F(f) Y_t^F(f)$ and total expenditure, which includes 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 in the rest of the world market.

2.4 The Government

The fiscal block of the model is detailed enough to allow for the assessment of macroeconomic impacts of alternative fiscal policy strategies. Government has a number of fiscal instruments that can be used to stabilise the business cycle that affect macroeconomic aggregates differently. In addition, Government may also finance current expenditure using future tax revenues by managing a public debt stock subject to full home bias. The public sector account disaggregation considered is illustrated in Table 1.

On the expenditure side, the government faces spending with: the government consumption good, $P_t^{\mathcal{G}} G_t$ (recall that $P_t^{\mathcal{G}}$ is the price charged by distributors for the government consumption good); lump-sum transfers to households, TRG_t; and 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 receives funds from: foreign transfers from the rest of the world, TRE_t; the labour income tax paid on wage income, $RV_{L,t} = \tau_{L,t} \left(V_t U_t - P_t \Gamma_t^U \right)$; the tax paid by households on consumption expenditures, $RV_{C,t} = \tau_{C,t} P_t^{\mathcal{C}} C_t$; employers' social security contributions due on payroll, $RV_{SP,t} = \tau_{SP} V_t U_t$; corporate income taxes paid by firms (both manufacturers and distributors) on operational profits, $RV_{K,t}$, defined as:

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

It should be noted that the government finances its expenditures mostly through taxation (present or future), and that most taxes are distortionary. For instance, higher taxation on labour income and/or higher social security contributions rate induce households to substitute consumption by leisure and/or manufacturers to use technologies with higher capital intensity. An increase in the consumption tax rate also induces households to substitute away from consumption.

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	$-(B_t - B_{t-1})$		

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. To simplify, full home bias is assumed, implying that all domestic debt is held by domestic households. However, households can access international debt markets and borrow abroad to buy the domestic government bonds.

The 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 total revenues.

To ensure that the public debt B_t 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 also 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 Government budget constraint is binding and at least one of the fiscal instruments must adjust endogenously to fulfil the budget constraint. Following Kumhof and Laxton (2008), this rule takes the following form:

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

where RV_t^{ss} is overall tax revenue with tax bases evaluated at their steady-state levels; GDP_t and GDP_t^{ss} are observed and steady-state levels of Gross Domestic Product. The convergence dynamics, namely the speed of convergence and the response to business cycle fluctuations, depend on the fiscal rule parameters. Parameter d_1 controls for the response to tax revenue gap, while d_2 controls for the Government (in)tolerance to deviations of debt from the target debt ratio. Since these gaps vanish in the steady state, the rule implies that fiscal balance and debt converge to their target levels.

At this point, the fiscal instrument that becomes an endogenous variable 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 asset holders or liquidity constrained 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 ($\tau_{K,t}$).[5] However, *ex-post* one of this instruments is endogenously adjusted to met the fiscal balance imposed by the fiscal rule.[6] The most common option relies on the use of the labour income tax rate as the endogenous fiscal policy instrument (Harrison et al. 2005, Kilponen and Ripatti 2006, Kumhof and Laxton 2007*a*, Kumhof and Laxton 2007*b*). 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 types of fiscal simulations, the model remains a simplification of reality that is crucial to keep it tractable. In particular, government consumption represents a pure distortion, since it does not affect the marginal utility of consumption and leisure or 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. If Government purchases includes more spending on law enforcement, road buildings or other public stock with likely future effects, these are not considered. 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 modelled.

2.5 The rest of the world

By assumption the rest of the world (RoW) corresponds to the rest of the monetary union, and therefore the nominal effective exchange rate is irrevocably set to unity, as all trade and financial flows are in the same currency.

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

[5] The distinction between government consumption and investment is not considered in the model.

[6] 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 2.3 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 his country that minimises the cost of producing the desired quantity of assembled good, subject to the technology constraint imposed by (23). Aggregating across importers and export goods 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 final export good charged by 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 highly relevant to render the model dynamically stable, namely due to a large elasticity to real exchange rate movements. The model operates *de facto* like a real model (or a fully credible fixed nominal exchange rate model), since domestic price levels are pinned down by the external constraint that uniquely sets the steady-state real exchange rate level. Like all 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 of the external environment for the purpose of analysis in many euro area SOE, for fiscal policy analysis it does not seem very stringent and allows for minimising the dimension of the external block of the model. 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 high 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 model are endogenously determined by imports demand of their trading partners, in a SOE model foreign economy developments influence the domestic economy significantly, but are not influenced by domestic economy developments (Adolfson et al. 2007). Therefore, it seems reasonable to assume that total foreign demand and prices are exogenous, with endogenous movements in exports being simply determined by the behaviour of the real exchange rate.

2.6 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, output supplied by each type of distributor must meet demand by its respective costumer 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' net bond holdings must equal the economy's trade net position:

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

Finally, nominal GDP is given by:

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

while real GDP is defined as GDP evaluated at the prevailing initial steady-state price levels.[7]

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

2.7 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 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. Labour-augmenting productivity's annual growth rate was set to 2 per cent, which is consistent with the estimates for the euro area's long-run potential output growth (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 credibility. Hence, the steady-state was solved under the assumption that foreign inflation stands at 2 per cent per year. The euro area nominal interest rate in the steady-state was set to 4.5 per cent (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 and Laxton (2007*a*). The elasticities of substitution in the production functions of manufacturers and distributors, the parameters governing wage, price markups and adjustment costs, and also the fiscal rule parameters were calibrated using mainly Kumhof and Laxton (2007*a*) and Coenen et al. (2007) or estimates for Portugal, whenever they were available.

3 Fiscal stimulus under full credibility

The impact of fiscal policy instruments on the economy is a crucial piece of information for the policy making process. In the light of perfect foresight and full government credibility, this section addresses the following questions: how effective is a temporary fiscal stimulus on aggregate demand and output in a SOE operating in a monetary union? What is the best instrument in order to boost economic activity? Can implementation lags reduce the short-run multiplier? Is there a case for a permanent fiscal stimulus?

Figure 1 depicts a stylised example, where permanent and temporary fiscal stimulus are based on government consumption (G), though any instrument presented in subsection 2.4 could be used. The first relevant date of Figure 1 is t_l, when the government announces that a stimulus will be implemented. This is a relevant date as the government may feel the urge to announce the fiscal package before the stimulus is actually implemented, or because some time span may be legally needed before implementing the programme. The second date is t_0 – the implementation date – when G^{SS} (the steady state level of government consumption) actually increases to $G^{SS} + \Delta$. If $t_l = t_0$, then there is no implementation lag.

If the government actions are temporary (subsection 3.1) there will exist a period after t_1 in which the fiscal stimulus ceases to be in place. This corresponds in Figure 1 to a decrease in G towards the level prevailing before the stimulus. In this case, the government will have increased financing needs between t_0 and t_1 (the gray area), which will have impacts in the SOE that will remain in place even after t_1. If the government announces the package before the implementation date, date t_l is assumed to take place 4 quarters before the implementation. This possibility is analysed in subsection 3.2. If the stimulus is permanent, which is analysed in subsection 3.3, then $G^{SS} + \Delta$ becomes the new level for G.

In all simulations the fiscal rule is switched off between t_0 and t_2 to prevent the government from stimulate and consolidate simultaneously.[8] In all experiments, the time span from t_0 to t_1 and from t_1 to t_2 is assumed to be 4 quarters. Therefore, the fiscal rule is switched off since the implementation date for a period of two years. At t_2, it is assumed that the labour income tax τ_l starts moving to bring the government's debt back to its initial steady-state level. The fiscal rule is calibrated such that the return to the steady-state is gradual, therefore minimising the effects of fiscal consolidation on GDP. Finally, to increase the comparability between all fiscal instruments as potential best candidates for the stimulus, the fiscal boost is assumed to be such that it increases the ex-ante fiscal deficit in percentage of steady-state GDP by 1 per cent in all cases, which corresponds in Figure 1 to $G^{SS} + \Delta$.

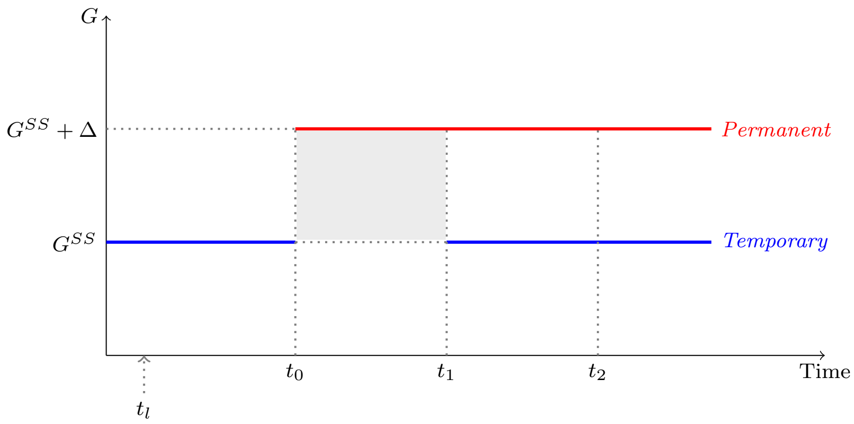
The role played by fiscal multipliers (FM) to address the effect of this type of measures on macroeconomic aggregates has been an important topic in the literature and used in several contexts (Spilimbergo, Symansky and Schindler 2009). If $FM > 0$ for GDP, or consumption, then a fiscal stimulus may be used to perform business cycle stabilisation.

The "impact multiplier" is the most commonly used FM (Blanchard and Perotti 2002, Canova and Pappa 2007). Essentially, it delivers the effect of the fiscal instrument on impact, which is typically assumed over the short-run and during the period in which the fiscal stimulus is implemented. The impact multiplier will be defined herein as the ratio between the change of the variable of interest and the ex-ante change of the fiscal balance as a percentage of steady-state GDP between t_0 and t_1, i.e. in the first year (which in our case is one by definition).

Moreover, fiscal measures produce an impact on periods beyond the short-run even if the stimulus is temporary. Therefore, besides the impact multipliers, this article also

[8]The switching off of the rule might rise issues related with the so-called time-inconsistency of optimal plans (Barro and Gordon 1983, Kydland and Prescott 1977). However, the discussion of the role of discretion is beyond the scope of this study. Nevertheless, conclusions would be qualitatively similar in case fiscal policy rule is switched on.

Figure 1: Fiscal stimulus based on G



Notes: t_0 is the starting date of the fiscal stimulus and when the fiscal policy rule is deactivated; t_1 is the ending date if the stimulus is temporary; t_2 corresponds to the starting date of the consolidation period in both the temporary and permanent cases, defined as a time when the fiscal policy rule is again fully operational; G^{SS} is the steady-state level of government consumption before the stimulus; Δ is the actual stimulus (it correspond in all experiments to a level that implies an ex-ante increase in the fiscal deficit of 1% of steady-state GDP); t_l is a possible announcement date (otherwise $t_l = t_0$). In all experiments, the time span between t_l and t_0 (if $t_l \neq t_0$), or t_0 and t_1, or t_1 and t_2 is assumed to represent 4 quarters.

presents the impulse response functions over a period of 10 years and the "present value multiplier" (PVM), following the proposal by Mountford and Uhlig (2009). The PVM corresponds to the present discounted value of the impact of a 1 per cent fiscal stimulus from period 0 up to period k at a discount rate that reflects economic agent relative concerns with impacts that occur farther in time vis-à-vis short-term impacts.[9]

Finally, the effects of a permanent increase in government consumption can also be assessed by analysing the welfare impacts associated with a permanent increase in government consumption.[10] In this paper, we consider a discrete time counterpart of the suggestion of Calvo and Obstfeld (1988), which has also been used in the literature (Ganelli 2005, Kumhof, Laxton and 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 additional units of consumption good in the steady-state. It is

[9] A brief description of the methodology used to compute the PVM is presented in Appendix B.

[10] In the case of the temporary shocks, the welfare effects are not mentioned because the impact is limited, given the temporary nature and the magnitude of the stimulus.

Table 2: Impact multipliers under alternative fiscal instruments

(deviation from steady-state)

	G	TRG	$TRG^{\mathcal{B}}$	τ_l	τ_c
GDP	1.02	0.24	0.57	0.37	0.38
Private consumption	0.90	0.78	1.86	0.71	0.96
Government consumption and investment	4.37	0.00	0.00	0.00	0.00
Private investment	-0.62	-0.18	-0.40	0.06	-0.09
Exports	-0.66	-0.32	-0.78	0.06	-0.19
Imports	0.65	0.29	0.71	0.29	0.37
Hours	1.66	0.23	0.63	0.48	0.40
Real wage rate	0.94	0.42	1.04	-0.79	1.56
Real exchange rate	-0.27	-0.13	-0.31	0.02	-0.08
Inflation (in %)	0.29	0.09	0.22	-0.03	-1.62
NFA (as a % of SS GDP)	-0.02	-0.03	-0.08	0.69	-1.07
Public debt (as a % of SS GDP)	0.12	0.46	0.18	-0.11	1.21

Notes: All variables are measured in percent deviations from the steady-state levels, except for inflation, net foreign assets, public debt and fiscal balance where deviations are in percentage points. "*SS* GDP" indicates *steady-state* GDP. Higher real exchange rate corresponds to a depreciation. The fiscal instruments are labour income taxes (τ_L); taxes on consumption goods (τ_C); general transfers (TRG); targeted transfers ($TRG^{\mathcal{B}}$); government consumption (G). Inflation is defined as the annual change in P_t, which is the numeraire price of the economy. The real exchange rate is computed with the prices of export goods.

worth mentioning that the current setup assumes that public consumption goods are not valued by households, an assumption that might be stringent. Nevertheless, the analysis is still useful to motivate the idea that permanent increases in government consumption negligibly valued by households, though expanding economic activity, are hardly welfare improving.[11]

3.1 Temporary stimulus without implementation lags

Table 2 presents the impact multipliers for the five fiscal instruments considered (government consumption, general transfers, targeted transfers, labour income tax and consumption tax), under the assumption of no implementation lags. The results indicate that all expansionary measures have positive effects on GDP and consumption in the first year, suggesting that fiscal stimulus may be envisaged to perform business cycle stabilisation. However, the impact on GDP is, in most experiments, significantly below unity, due to non-negligible leakages, namely related with savings and imports. In other words, the results suggest that, in most cases, a fiscal stimulus of 1 per cent of steady-state GDP causes actual GDP to increase by less than 1 per cent on impact.

The impact multiplier on GDP from a fiscal stimulus based on government consumption is 1.0 per cent. In case the fiscal stimulus is based on targeted transfers (transfers to liquidity-constrained households) the impact is 0.6 per cent, while if it is based on taxes,

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

both labour income and consumption, the impact is close to 0.4 per cent over the first year. Finally, the smaller impact on GDP (0.2 per cent) is obtained from an increase in general transfers (transfers to all households regardless of whether they are liquidity-constrained or not). Hence, the most effective fiscal instrument to stimulate the economy on impact is government consumption. This result is in line with the literature that points to larger multipliers from fiscal measures based on government consumption and public investment than those based on transfers or tax cuts.

A major reason behind the different magnitudes in the impact multipliers is the fact that fiscal stimulus delivered from government consumption feeds directly into aggregate demand, whereas the stimulus delivered from transfers or tax cuts operate mainly through the effect on current income and wealth (which is only partly used by asset holding households to increase private spending), as well as through their effects on incentives in case of changes in distortionary taxes. Moreover, while the increase in government consumption induces a small increase in the demand for imports, the remaining stimulus instruments increases demand for private consumption goods, which has a much higher import content. Besides the direct effect, government consumption also has indirect effects in demand derived from higher spending, which raises labour income and dividends and in turn increases private spending.

Finally, it is also important to stress that in a SOE integrated in a monetary union, with exogenous monetary policy, the impacts of fiscal stimulus measures on aggregate demand are amplified through the effect on real interest rates. This augmented effect is also present in the case of economies with endogenous monetary policy if the zero lower bound binds (Eggertsson 2009, Christiano et al. 2009) or under monetary accommodation (Freedman, Kumhof, Laxton, Muir and Mursula 2009). A fiscal expansion that puts upward pressure on inflation as demand increases, implies a decline in the real interest rates, since nominal interest rates are fixed, supporting and increasing the impact of fiscal policy on private spending. In the case of a fiscal stimulus based on targeted transfers and government consumption this effect is also key to explain the magnitude of the impact on aggregate demand.

Figure 2 presents the impulse response functions for the different stimulus measures over a ten years period. In most cases, given the temporary nature of the stimulus, the impact on GDP dies out or becomes even negative as soon as the shock is reversed. It is worth mention that of major importance will be the medium-run adjustment in real variables to cope with the impact of the fiscal shock that needs to be financed, which implies a protracted decline of aggregate demand to a level below the steady-state in the medium-run. Moreover, all shocks share the same outcome in which debt, fiscal balance and NFA to steady-state GDP return in the medium to long-run to their initial values due to the temporary nature of the stimulus.

Following the government consumption shock, households that access financial markets smooth their consumption by saving part of their additional income while liquidity-constrained households increase significantly their consumption. On the other hand, manufacturing firms have no incentive to adjust their capital stock upwards since the positive effect on domestic demand is highly temporary. Moreover, part of the increase in domestic demand is offset by the decrease in exports, due to a loss in competitiveness driven by higher prices. Indeed, the boom in public consumption implies an increase in demand for intermediate non-tradable goods, which are more intensive in labour services. Thus, the stimulus generates substantial demand side pressure on hours, implying higher wage inflation in the short-run to induce households to supply enough labour. This translates into higher marginal costs of intermediate goods production. Despite the downward adjustment in profit margins, domestic prices increase temporarily, leading to a significant real exchange rate appreciation with non-negligible temporary consequences on the economy's competitiveness. However, wage income does not increase significantly beyond the stimulus period, due to the absence of a sustained increase in demand, and therefore neither does the post-stimulus consumption of liquidity constrained households. After the first year, the nominal wage rate inflation reverts and the price level starts to gradually converge to the initial steady-state level. It should be mentioned that the impact on GDP is amplified by the anticipation of private consumption expenditures due to the temporary decline in the real interest rate.

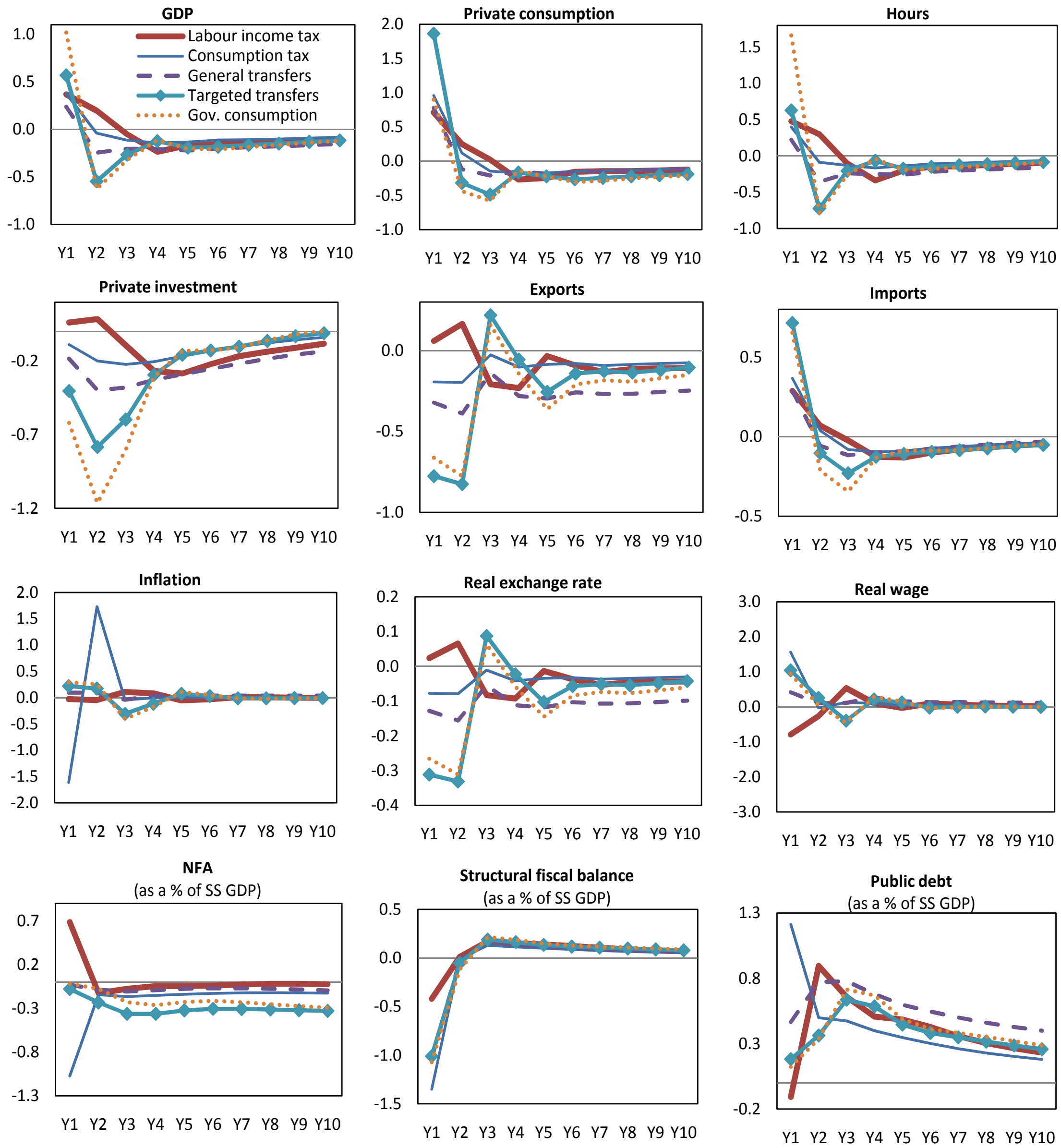
The simulated impact of an increase in general transfers on GDP is small, since the main effect comes from the increase in consumption of liquidity-constrained households.[12] The remaining households save part of these additional transfers as additional taxes will have to be paid in the future and so only a part of the increase in transfers is taken as a net wealth increase. Therefore, the shock based on targeted transfers provides a much more powerful stimulus than the one based on general transfers, more than two times larger in both GDP and consumption. Given that the transmission channels behind the two shocks are very similar, the rest of the discussion will be centered on the one that has a higher effect, that is, the targeted transfers.

The qualitative impact on the macroeconomic scenario of increasing targeted transfers is similar to that of government consumption, though in a smaller magnitude. An increase in targeted transfers stimulates the economy through the demand for private consumption goods and, as in the previous scenario, it implies a protracted decline of GDP and private consumption to below steady-state level as soon as the fiscal stimulus is reverted. The short-run increase in the demand for private consumption goods induces significant demand side pressure on labour and so an higher wage rate is required in order to motivate households to supply enough labour. The rise in firm's marginal costs is transmitted to intermediate and final goods prices. The temporary increase in inflation implies, on the one hand, a real exchange rate appreciation and a decrease in exports with the consequent deterioration in the net foreign asset position. On the other hand, it implies lower real interest rates which fosters some anticipation of consumption expenditures from households that have access to assets markets. However, the increase in wages is less marked than in

[12]Liquidity-constrained households are calibrated to represent about 40 per cent of total population. See Appendix A.

Figure 2: Impulse responses under alternative fiscal instruments

(deviations from steady-state)



Notes: All variables are measured in percent deviations from the steady-state levels, except for inflation, net foreign assets, public debt and fiscal balance where deviations are in percentage points. "*SS* GDP" indicates *steady-state* GDP. Higher real exchange rate implies depreciation. Inflation is defined as the annual change in P_t, which is the numeraire price of the economy. The real exchange rate is computed with the price of export goods.

the case of public consumption expansion, reflecting the fact that private consumption is less intensive in labour services.

In the case of labour income tax cut the positive impact on GDP and consumption extends beyond the stimulus period, although the impact multiplier is smaller than those reported for government consumption and targeted transfers. First, the labour income tax is distortionary, having significant effects on the households' consumption/leisure decision. The tax cut implies that households earn a higher labour income for the same wage paid by firms and, therefore, labour supply increases and the equilibrium wage declines, contrary to what happens in the case of the increase in government consumption and/or government transfers. The decline in wages on impact translates into a slight decrease in inflation over the first two years. In contrast with the effect of an expenditure based fiscal stimulus, this fiscal policy shock induces a slight short-run real exchange rate depreciation, improving competitiveness of domestic goods, which has a positive short-run effect on exports and on the net foreign asset position. The indirect effect from the decline in the real interest rate is negligible in the case of labour income tax cut, since the increase in inflation is small.

Finally, the impact multiplier of a consumption tax-based stimulus on GDP is similar to the one obtained for labour income tax, although the impact is less persistent. A consumption tax cut increases real wages, augmenting households' real income and therefore consumption. The cut in consumption tax produces a huge relative price change implying a broadly based increase in relative prices of all goods (both intermediate and final). This implies a stronger increase of the fiscal deficit and public debt, reflecting the sizeable increase in expenditure due to the hike in the relative price of public consumption. On the external side, the increase in the relative price of exports and imports implies a hike in the current account deficit that translates into a deterioration of the NFA position of the the SOE on impact. As soon as the shock is reversed, the increase in domestic demand pressures wages upwards in order to induce households to supply labour, inducing an increase in firms marginal costs and in domestic prices, which is similar to what was described for the fiscal stimulus based on government expenditures and transfers.

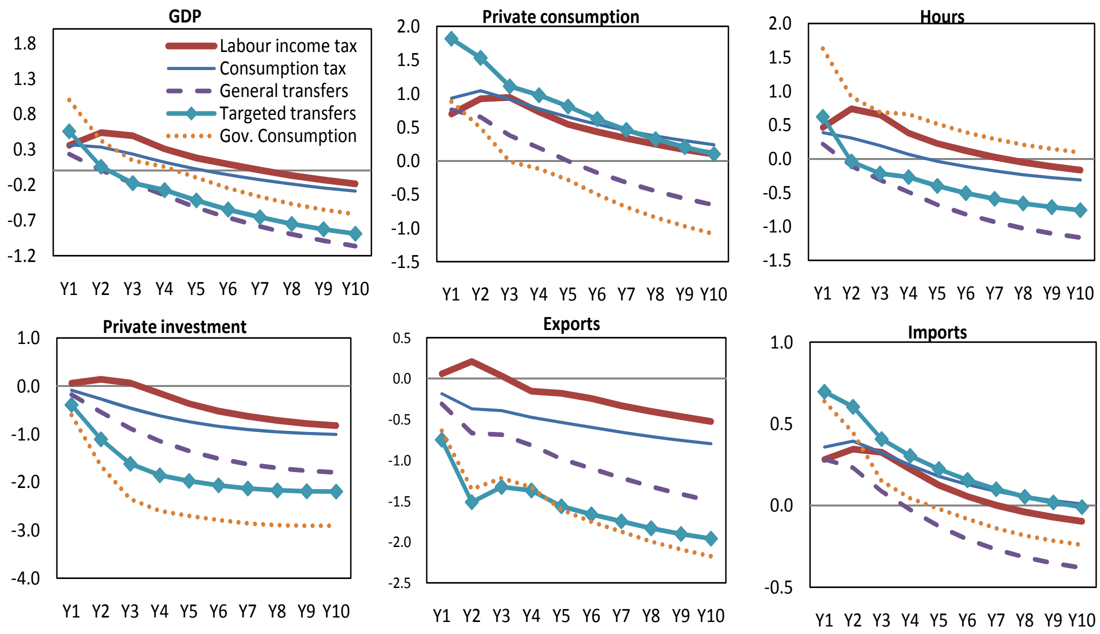
A slightly different way of assessing the impact of the fiscal stimulus in medium-term perspective relies on the present value multiplier (PVM) definition. Figure 3 presents the present value multiplier for the five fiscal stimulus measures up to period 10 years (40 quarters) ahead. The results reinforce the conclusion that in the medium run a fiscal stimulus has a negative effect on aggregate demand, which translates into a negative PVM from the second year onwards in the case of transfers (both general and targeted transfers) and from the seventh year onwards in the case of the labour income tax cut. The remaining cases lie in between.

Summing up, a fiscal stimulus can be effective in providing some temporary support to a SOE, nonetheless with non-negligible adverse impacts over the medium run. Similar fiscal multipliers have been reported in the literature for large economies, namely if the zero lower bound binds (Eggertsson 2009, Christiano et al. 2009) or under monetary accommodation (Freedman, Kumhof, Laxton, Muir and Mursula 2009). A major difference is nevertheless that while the (fixed) zero lower bound in large economies is an exception (of operating with positive interest rates), the exogenous (fixed) interest rate for a SOE in a monetary union is a predictable event.

Moreover, the size of the fiscal multiplier largely depends on the type of instrument

Figure 3: Present value multipliers

(deviation from steady-state)



Notes: The reported figures were defined in equation 34 and represent the $PVM(k)$, where $0 < k < 40$.

used and thus the fiscal stimulus package should be carefully designed. The highest impact on GDP comes from fiscal measures based on government consumption, notwithstanding that in what concerns investment projects it could imply long lags in planning and implementing. Fiscal measures based on targeted transfers have also a high short-term impact on GDP and have the advantage of being faster to implement. However, there is some risk of difficulty of reversal. Finally, it should be emphasized that in most cases, particularly in tax cuts, the fiscal stimulus implies significant leakages into saving and imports, and thus have a lower impact on GDP.

3.2 Temporary stimulus with implementation lags

This subsection analyses the sensitivity of aggregate demand to the timing of the fiscal stimulus. In practice, some changes in fiscal policy are likely to involve a particulary long period between the time of the announcement and its implementation. We define the time span between the former and the later as the "implementation lag". The presence of these lags is widely pointed against using fiscal policy as a tool to pursue business cycle stabilisation effects.

In the rest of this subsection all experiments are conducted assuming a fiscal stimulus based on government consumption, though conclusions would be qualitatively similar if the exercise had been conducted using the alternative instruments. As described in Figure 1, t_l is the date when the government announces that a stimulus will be implemented, and one year after, in t_0 (the implementation date), is when the government actually increases

Table 3: Impact multipliers under alternative timing scenarios

(percentage deviation from initial steady-state, unless otherwise indicated)

	Benchmark			Delayed		
	Y1	Y2	Y3	Y0	Y1	Y2
GDP	1.02	-0.63	-0.32	-0.13	0.73	-0.69
Consumption	0.90	-0.44	-0.58	-0.09	0.56	-0.55
Government consumption and investment	4.37	0.00	0.00	0.00	4.37	0.00
Private investment	-0.62	-1.16	-0.80	-0.27	-1.08	-1.40
Exports	-0.66	-0.78	0.16	-0.20	-0.92	-0.71
Imports	0.65	-0.21	-0.34	-0.11	0.40	-0.31
Hours	1.66	-0.79	-0.26	-0.19	1.19	-0.83
Real wage rate	0.94	0.04	-0.45	0.08	0.81	-0.24
Real exchange rate	-0.27	-0.31	0.06	-0.08	-0.37	-0.28
Inflation (in %)	0.29	0.25	-0.41	0.09	0.37	0.09
NFA (as a % of SS GDP)	-0.02	-0.08	-0.23	0.06	0.11	0.00
Public debt (as a % of SS GDP)	0.12	0.34	0.71	-0.02	0.21	0.62

Notes: All variables are measured in percent deviations from the steady-state levels, except for inflation, net foreign assets, public debt and fiscal balance where deviations are in percentage points. "*SS* GDP" indicates *steady-state* GDP. Higher real exchange rate corresponds to a depreciation. Inflation is defined as the annual change in P_t, which is the numeraire price of the economy. The real exchange rate is computed with the prices of export goods. In the case of the "Delayed" scenario $Y0$ corresponds to the announcement year and $Y1$ to the implementation year.

G to $G^{SS} + \Delta$. As in the previous exercise, the fiscal rule is switched off in the two years after the implementation of the new measure, that is, until t_2 and the structural fiscal deficit increases 1 per cent over one year.

Table 3 compares the results over a period of three years of an increase in government consumption with and without a lag between the announcement and the implementation date. The first set of results, which extends the results presented in the previous section, is called the "Benchmark" scenario. The experiment of this section is called the "Delayed" scenario.

As soon as the government announces the fiscal stimulus, households with access to financial markets start to adjust their consumption as they know that the government will increase taxes in the future in order to finance additional expenditures, since public debt to GDP ratio converges to its target level. The decrease in consumption expenditures after the announcement of the fiscal measure pushes private demand for domestic intermediate goods downward, affecting particulary labour demand. Hours worked decrease on impact and the same applies to wages. As a consequence of the decrease in current income, liquidity-constrained households adjust their consumption expenditures downwards. As soon as the fiscal measure is actually implemented the reverse occurs. Domestic demand increases in this year and so does labour demand and wages. After that, the transmission channel is similar to the one from the "Benchmark" scenario, although the impact on aggregate demand and on output is significantly smaller.

Summing up, the results indicate that possible lags between the announcement and the implementation of a fiscal stimulus should be taken into account, since they affect the effectiveness of fiscal instruments to pursue business cycle stabilisation objectives. This result is also highlighted in the literature (Erceg and Lindé 2010). Thus, the stimulus measures must be enacted quickly, minimizing the lags associated with their design, approval and implementation.

If domestic authorities are not prepared to choose timely fiscal stimulus, particulary if they are conditioned by a complex decision process or by time-consuming bureaucracy standards, the initial objectives may be hindered. In addition, the higher the delay the higher the probability of inadequacy, namely if the economy was in the meantime hit by other shocks.

3.3 A permanent increase in government consumption

When a fiscal stimulus is implemented there is a significant risk of being difficult to reverse it in the near future. Therefore, it seems important to analyse the short-run and long-run consequences on aggregate demand and output of a permanent increase in government consumption.

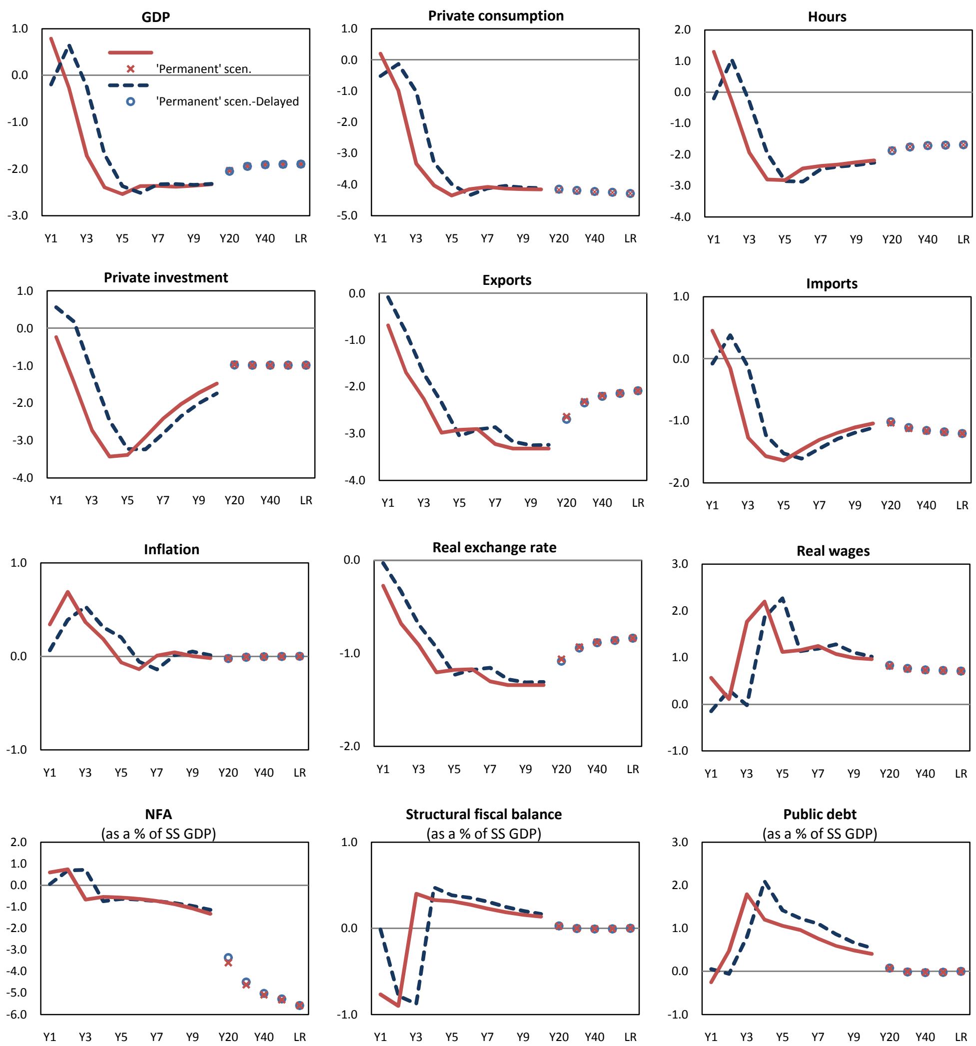
In this subsection two scenarios are implemented. As illustrated in Figure 1, the first one corresponds to a permanent increase in government consumption of 1 per cent of the initial steady-state GDP level, announced and implemented in t_0 of (henceforth "Permanent" scenario). The second scenario corresponds also to a permanent increase in government consumption of the same magnitude, announced also in t_0 but implemented only in t_1 (henceforth "Permanent" scenario - Delayed). The fiscal rule is switched off during the two years after the implementation of the stimulus. Thereafter, the Government starts to consolidate by increasing the labour income tax rate in order to bring the government debt ratio back to its target value. The stimulus package and the fiscal instrument used to consolidate are announced from the outset and are assumed to be fully credible.

Figure 4 illustrates the impulse response functions for the two scenarios and highlights the negative long-run effects of a permanent increase in government consumption. The impact multiplier on GDP of a permanent increase in government consumption is smaller than in the case of a temporary shock and is even smaller if the implementation is lagged by one year, mainly reflecting the wealth effects of the fiscal stimulus on consumption of households with access to asset markets. The increase in the present discounted value of taxes implies a negative wealth effect that crowds out partially private demand in the short-run.

After the second year, as the fiscal consolidation begins, the impact on GDP and on demand components becomes strongly negative, as a result of the real exchange rate appreciation and the increase in labour income tax rate required to finance permanently higher government spending. The permanent increase in the labour income tax rate, which is highly distortionary, implies a strong disincentive to supply labour, which affects significantly the consumption/leisure choice. In the final steady-state, real wages and hours

Figure 4: A permanent increase in government consumption

(deviation from initial steady-state)



Notes: All variables are measured in percent deviations from the steady-state levels, except for inflation, net foreign assets, public debt and fiscal balance where deviations are in percentage points. "*SS* GDP" indicates *steady-state* GDP. Higher real exchange rate implies depreciation. Inflation is defined as the annual change in P_t, which is the numeraire price of the economy. The real exchange rate is computed with the prices of export goods. *LR* indicates the long-run impact and corresponds to a time horizon of 238 years

will be, respectively, above and below the initial steady-state. Given that households are non-Ricardian, part of the increase in public debt is taken by households as net wealth. Therefore, the public debt increase is partly financed by resorting to external debt, implying only a limited crowding-out of private expenditure.

The impact on households' welfare measured by the compensated consumption variation from a permanent increase in government consumption is presented in Table 4. The results are very similar for both scenarios and point to a significant negative impact of a permanent increase in government consumption expenditures in households welfare vary-

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
"Permanent" scenario				
All	-11.0	-10.3	-9.4	-5.7
OLG	-11.4	-10.5	-9.5	-5.7
LIQ	-10.0	-9.7	-9.2	-5.7
"Permanent" scenario - Delayed				
All	-10.9	-10.0	-8.9	-4.5
OLG	-11.3	-10.3	-9.0	-4.7
LIQ	-10.0	-9.5	-8.7	-4.1

ing from -4.1 per cent to -11 per cent according to the scenario considered and the above mentioned weighting factor.

Summing up, the simulation presented in this subsection illustrates the importance of the fiscal stimulus reversal to sustain economic performance and maintain macroeconomic stability in the medium and long-run. If a fiscal stimulus is not reversed the impact could be positive in the short-run (although less favourable than in the case of a temporary fiscal expansion), but with very unfavourable consequences in the long run. The output losses from a permanent increase in government consumption are higher than the short-run stimulus effects. In other words, the long-run costs far exceed the short-run benefits. This result is similar to the one reported in the literature (Cogan et al. 2009, Freedman, Kumhof, Laxton and Lee 2009, Coenen et al. 2010).

4 Fiscal stimulus under limited credibility

This section illustrates how credibility issues can affect the results obtained in the previous section. In particular, the mis-perception by the private sector on the government commitment to reverse the fiscal stimulus is addressed in subsection 4.1. Furthermore, the question whether the authorities should implement a fiscal stimulus should not be addressed without taking into account other possible effects, particularly the impact on foreign risk premium. The increase in the foreign risk premium on public debt has acquired importance recently, specially in the case of economies participating in the euro with sizeable fiscal imbalances and high levels of external indebtedness. Therefore, it seems important to analize the possibility that the fiscal stimulus may bring about an increase in the risk premium. This issue is studied in subsection 4.2.

4.1 The withdraw of a fiscal boost

Table 5 presents the effects of a fiscal stimulus under mis-perception of government actions, but abstaining from any impact on the risk premium on government debt. As in the previous simulations, the fiscal stimulus corresponds to an increase in the structural fiscal

Table 5: Impact multipliers under alternative credibility scenarios

(percentage deviation from steady-state level, unless otherwise indicated)

	Bechmark			Mis-perception		
	Y1	Y2	Y3	Y1	Y2	Y3
GDP	1.02	-0.63	-0.32	0.79	-0.73	-0.30
Private consumption	0.90	-0.44	-0.58	0.20	-0.79	-0.64
Government consumption and investment	4.37	0.00	0.00	4.37	0.00	0.00
Private investment	-0.62	-1.16	-0.80	-0.24	-0.96	-0.66
Exports	-0.66	-0.78	0.16	-0.69	-0.87	0.06
Imports	0.65	-0.21	-0.34	0.45	-0.36	-0.38
Hours	1.66	-0.79	-0.26	1.30	-0.97	-0.33
Real wage rate	0.94	0.04	-0.45	0.56	-0.45	-0.46
Real exchange rate	-0.27	-0.31	0.06	-0.28	-0.35	0.03
Inflation (in %)	0.29	0.25	-0.41	0.34	0.30	-0.53
NFA (as a % of SS GDP)	-0.02	-0.08	-0.23	0.59	0.07	-0.15
Public debt (as a % of SS GDP)	0.12	0.34	0.71	-0.25	0.64	1.09

Notes: All variables are measured in percent deviations from the steady-state levels, except for inflation, net foreign assets, public debt and fiscal balance where deviations are in percentage points. "*SS* GDP" indicates *steady-state* GDP. Higher real exchange rate corresponds to a depreciation. Inflation is defined as the annual change in P_t, which is the numeraire price of the economy. The real exchange rate is computed with the prices of export goods.

deficit by 1 per cent of steady-state GDP over one year due to higher government consumption. The "Benchmark" scenario is the same as before, while the "Mis-perception" scenario corresponds to a situation in which the government announces and implements a temporary fiscal measure, but the private sector assumes that the stimulus is permanent. It is only in the second year, when the government actually suppresses the stimulus, that households and firms recognise that the government kept its original promise.[13]

The results from the simulation of the "Mis-perception" scenario point to a smaller impact on GDP and consumption in the first years of the stimulus when compared with the "Benchmark" scenario. This difference mainly reflects the wealth effect of the fiscal stimulus on consumption of households with access to asset markets, since they assume during the first year that the increase in government consumption is permanent and that the government will further increase labour income taxes in the future in order to bring the debt ratio to its target level. From the second year onwards, when the private sector realizes that the government will in fact deliver its originally promised deficit profile, the effects are similar to the ones from the "Benchmark" scenario although less favourable. All in all, the effectiveness of fiscal policy to stimulate aggregate demand is smaller in the case of mis-perception on the reverse of the fiscal expansion than in the case of perfect credibility.

[13] If one were to use Figure 1, this experiment corresponds to a situation where the temporary fiscal stimulus takes place in $t_l = t_1$ but, due to lack of credibility, all agents of the SOE assume that the stimulus is permanent. It is only at time t_1 that is recognised that the government actually suppresses the stimulus.

4.2 Risk premium effects

In the run up to the euro, government debt yield spreads of euro area countries vis-à-vis Germany Bunds declined to very low levels. However, the outbreak of the financial crisis in mid-2007 and its intensification at the end of 2008 triggered a very significant increase in the sovereign risk premium, which has been particulary marked in some euro area countries, notably in Greece, Portugal and Spain, albeit with different magnitudes. Therefore, it seems important to assess the impact of a fiscal stimulus in a context of financial distress, in which case it might be reflected in an increase in the interest rate risk premium.

In the previous simulations, it was assumed that the risk premium on government debt is not affected by the debt issuance required to finance the fiscal stimulus. This implies that domestic and international financial conditions are regular and that the consolidation strategy is fully credible. In the case of limited credibility, i.e. when there are doubts about the future of fiscal sustainability, the implementation of a stimulus programme may imply a rise in the risk premium that can diminish or even offset the impact of the programme. This scenario is illustrated in this subsection.

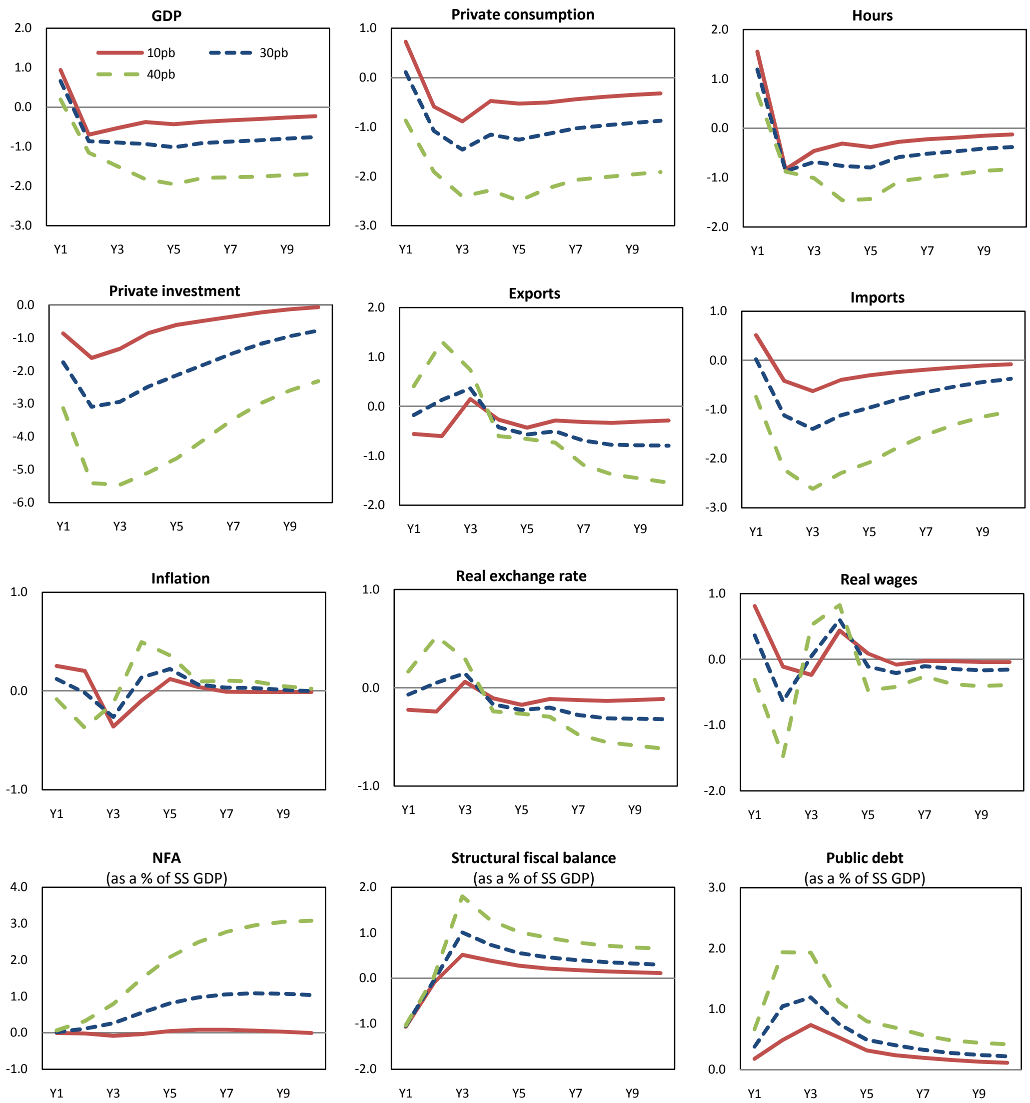
To assess the impact of an increase in the risk premium stemming from the implementation of a temporary increase in government consumption, the risk premium demanded by investors to hold domestic bonds is assumed to depend on the deviation of public debt from target. The larger the deviation from actual to target debt ratio, the higher the risk premium. When the debt returns to its steady state value, the risk premium returns to its initial value. A sensitivity analysis is conducted using alternative calibrations for the impact on the risk premium from deviations of the debt ratio from its target level. The benchmark level, 10 basis points for each one-percentage-point increase in the debt ratio, was based on Ardagna, Caselli and Lane (2004) and corresponds to the impact on a country with above-average levels of debt (in a panel of 16 OECD countries) over the period 1960 to 2002. The other two calibrations (30 and 40 basis points) are closer to the recent situation of turbulence in the financial markets, when the risk premium on public debt increased sharply in some euro area countries with high levels of external indebtedness (Schuknecht, von Hagen and Wolswijk 2010).

Figure 5 illustrates the results from the above-mentioned exercise comparing different calibrations for the sensitivity of the risk premium. The results point to a restrictive impact in domestic demand from an increase in the risk premium, implying that the government consumption multiplier on economic activity is lower in case the risk premium rises as a response to higher government debt. Moreover, if the stimulus triggers a sizeable increase in the risk premium, the impact of the stimulus may be fully offset.

The increase in the risk premium directly affects households and firms decisions, with a negative impact on private consumption and investment, and implies an increase in Government interest outlays. In fact, it leads to a significant protracted decline in private consumption, mainly resulting from changes in decisions concerning consumption and asset

Figure 5: Government consumption shock with increase in interest rate risk premium

(percentage deviation from baseline level, unless otherwise indicated)



Notes: All variables are measured in percent deviations from the steady-state levels, except for inflation, net foreign assets, public debt and fiscal balance where deviations are in percentage points. "*SS* GDP" indicates *steady-state* GDP. Higher real exchange rate implies depreciation.

holding of households with access to asset markets. It reflects a higher discount on future income, which reduces wealth and has a negative effect on consumption (wealth effect). Additionally, the rise in the risk premium induces, *ceteris paribus*, an increase in the real interest rate, which increases the return on savings (or cost of debt), measured in terms of future consumption, thereby providing a further desincentive to present consumption (substitution effect). Additionally, the increase in government interest outlays and debt increases labour income taxes, implying an additional negative wealth effect and a shift away from consumption to leisure. Private investment also suffers a protracted decline reflecting a lower desired capital level, due to both the increased real interest rate and the lower demand prospects which have a negative effect on dividends prospects.

In summary, when the private sector worries about fiscal sustainability drive up the interest rate risk premium, the positive effects of a fiscal stimulus are clearly mitigated. Therefore, a credible promise of fiscal discipline is critical even for the short-run effectiveness of the stimulus. All depends on the actual risk premium increase. The credibility of the fiscal stimulus and its adequacy to the prevailing financing conditions and government debt levels should always be assessed to gauge the downside risks surrounding the impact of fiscal stimulus packages.

5 Conclusions

This paper discussed alternative fiscal stimulus for a SOE operating in a monetary union. The discussion was conducted using *PESSOA*, a New-Keynesian dynamic general equilibrium model with exogenous monetary policy, specially designed to fit the characteristics of a small euro area economy.

The fiscal stimulus was assumed to imply an increase in government deficit of 1 percent of steady-state GDP for one year. In addition, the fiscal policy rule that prevents unsustainable public debt developments was assumed to be deactivated for two years. Under these circumstances, the most effective policy instrument to promote growth in the sort run is a temporary increase in government consumption. The results indicate that such stimulus also increases actual GDP by around 1 per cent of its steady-state value during one year. In case the fiscal stimulus is based on targeted transfers (transfers to liquidity-constrained households) the impact is 0.6 per cent, while if it is based on taxes, both labour income and consumption, the impact is close to 0.4 per cent. The smaller impact (0.2 per cent) is obtained from an increase in general transfers (transfers to all households regardless of whether they are liquidity-constrained or not). The main reason behind that outcome is twofold. On the one hand, government consumption feeds directly into aggregate demand, whereas the other instruments operate mainly through wealth effects, with leakages to savings, which reduces the fiscal multiplier on impact. On the other hand, government consumption has a much lower import content than private consumption, implying less leakages to imports.

The government should however refrain from implementing a permanent increase in government consumption, since the long-run costs far exceed the short-run benefits. Welfare analysis showed that a permanent increase in government consumption would be equaled by a permanent decrease in wealth measured by a decrease in private consumption in the new steady-state.

The results also point that the government should avoid to take actions that are not timely or fully credible. In both cases the fiscal multipliers are diminished and the stimulus may even backfire, having counterproductive effects. This is likely to be the case for economies in financial distress, in which the stimulus may trigger a surge in the sovereign risk premium. In this case, not to implement any stimulus might be the best strategy from an economic point of view, in particular in case the rest of the monetary union is engaged in a fiscal stimulus program, from which the domestic economy can beneficiate indirectly through the trade channel. However, one must be aware that this corresponds to a free-riding behaviour, which may raise issues on a common euro area strategy. Nevertheless, it should also be taken into account that a surge in the sovereign risk premium in a small euro area economy may generate spill-over effects over the other member states and ultimately jeopardise the credibility of the area as a whole in international financial markets. Therefore, the design of a successful stimulus programme for the area as a whole, in a situation of financial distress, should take into account the specific financial situation of each one of the constituent economies.

Finally, even when the fiscal stimulus is fully credible and without implementation lags, national governments should expect adverse impacts over the medium and longer run. The fiscal stimulus is always an option that needs to be financed after some well-defined point in the future. Given that the model operates *de facto* like a real model, regaining stability requires real adjustments, including negative GDP and private consumption growth.

The main qualitative result is therefore that although national governments can use fiscal policy to pursue some macroeconomic stabilisation objectives, namely in the short run, the available instruments are far from being Panacea, the Greek goddess of healing.

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Appendices

A Model calibration

This appendix reports in some detail the model parameters (see 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.[14]

The calibration of households' parameters took into consideration that the model comprehends Blanchard-Yaari overlapping generations, while most DSGE models consider the infinitely-lived agents framework. These parameters were therefore largely based on Fagan, Gaspar and Pereira (2004), Harrison et al. (2005), Kumhof and Laxton (2007*a*) and Kumhof and Laxton (2007*b*). $\eta_{\mathcal{A}}$ 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 per cent in the steady-state. The coefficient of relative risk aversion was set to calibrate the intertemporal 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 it 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 per cent, broadly in line with the estimates for Portugal presented in Castro (2006).

In terms of labour unions' parameters, we considered a 25 per cent 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 NA 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 NA data. The price markup of tradable and non-tradable goods' manufacturers 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 non-tradable goods markup was set to 20 per cent, 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 non-tradable goods market. As for

[14]The Portuguese national accounts do not include figures for 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

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 and Laxton (2007*b*)); 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 and Laxton (2007*b*). The distribution parameters of the production function in each stage were calibrated to match the NA 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 markup being set to 5 per cent, except in the case of exporters, where fiercer competition is likely to determine a lower markup. In terms of price stickiness, an average duration of price contracts of 2 quarters was assumed for all distributors except for exporters, whose prices are assumed to adjust slightly 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.

Government's average tax rates were calibrated to match the share of revenue-to-GDP ratio 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 impose a structural budget balance rule (unit fiscal policy stance parameter) and to ensure a smooth labour income tax rate adjustment. The target debt-to-GDP ratio was set to 53 per cent, implying a fiscal balance-to-GDP ratio of -2.1 per cent in the steady-state.[15]

[15]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 per cent, implying a debt-to-GDP ratio of close to 12 per cent). However, since in the historical period that was used to calibrate the model the debt-to-GDP ratio averaged 57 per cent, it does not seem reasonable to calibrate it to match something substantially different from historical figures.

B Present value multipliers

The present value multiplier (PVM) is computed following the proposal by Mountford and Uhlig (2009) that has already been used in the context of general equilibrium models (Leeper, Plante and Traum 2009). For any variable of interest, the assessment delivered by the present value multiplier up to period k can be expressed as:

$$PVM(k) = \frac{\sum_{j=0}^{k}(\beta\theta)^j \hat{Y}_{t+j}}{E_t \sum_{j=0}^{k}(\beta\theta)^j \hat{sg}_{t+j}} \tag{34}$$

where $\hat{Y}_t$ refers to deviation from steady-state of variable Y in period t, $\hat{sg}_t$ refers to deviation from steady-state of fiscal balance-to-GDP ratio in period t and $\beta\theta$ stands for the household discount factor β adjusted by θ, the degree of myopia. Typical candidates for Y can be, for instance, GDP or private consumption.

C 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 per cent. 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 per cent; a very low discount rate $W_L = 0.1$ per cent, 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 per cent 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 discount rate of 0.1 per cent 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 per cent 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:

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

Appendix - Figure 1: Welfare weighting scheme

(in percentage)