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Estimates of Fiscal Multipliers using MEDSEA

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Abstract

This paper documents the fiscal extension to MEDSEA, the Central Bank of Malta DSGE model. The model contains a relatively rich fiscal sector. Decisions made by the agents in the model are affected by distortionary taxes on labour income, capital income and consumption. On the expenditure side, the model distinguishes between public sector expenditure on final goods and services, public investment, public employment as well as transfers to households. The model is used to assess the size of fiscal multipliers in a very open and small open economy such as Malta. I consider both transitory and permanent shocks and also allow for changes in the instrument used to finance the change in fiscal policy.

JEL Classification: E62, H63 **Keywords:** Fiscal multipliers, general equilibrium models

Contents

1 Introduction

The financial crisis of 2008 as well as the more recent sovereign debt crisis, have obliged governments to embark on ambitious fiscal expansionary programmes designed to sustain the world economy in the midst of the deepest economic crisis since the Great Depression, while at the same time devise exit strategies designed to guarantee the sustainability of public finances. The formulation of such a strategy requires policy makers to answer two distinct yet related questions. First, which is the most efficient way to sustain real economic growth; in other words which fiscal instruments are likely to stimulate the economy the most for a given impact on government debt? Second, which are the most efficient ways to consolidate public finances; thus, should the government cut expenditure or raise taxes and what are the macroeconomic and welfare implications of these measures?

This paper contributes to this debate by developing a DSGE model with a detailed fiscal sector for the Maltese economy. DSGE models are regarded as reliable tools that can provide valuable insights to policymakers with regards to evaluating fiscal policy alternatives. In 2016, the Central Bank of Malta has published MEDSEA (Rapa, 2016), a new DSGE model for the Maltese economy. MEDSEA is a small open economy model, similar in nature to Gali and Monacelli (2005), but contains key modifications designed to account for Malta's characteristics. In particular, in line with Almeida et al. (2013), the Maltese economy is modelled within a monetary union, thereby lacking an independent inflation targeting rule. Furthermore, the model features an export sector which has been specifically designed to account for Maltese characteristics. Unlike similar models in its class, the tradable production of the model is made up of intermediate production that is explicitly targeted to be exported and is therefore not complementary to other non-tradable production meant for the domestic market. This feature reflects the fact that goods and services meant for consumption and investment are intrinsically different from those that are exported.

The basic framework in Rapa (2016) has a very stylised treatment of fiscal policy making the model unable to contribute to the above discussion. To this end I choose to extend MEDSEA by introducing a detailed fiscal policy block. On the government revenue side, Ricardian equivalence is broken by the presence of distortionary taxes on consumption, labour and capital. On the government expenditure side the model distinguishes between government consumption, government investment as well as transfers to households. The former is in turn divided into government purchases of goods and services and public sector wage bill that are used to produce a homogenous public good that enters the household utility function. Unlike other models in its class, MEDSEA allows both government expenditure on goods and services for consumption purposes and public investment to contain different degrees of import content. In light of the relatively open nature of the Maltese economy, this feature is believed to be very important so as to correctly measure the impact of changes in these fiscal instruments.

Moreover, the model departs from the simplifying assumption that government expenditure is "pure waste". Instead I introduce a trade-off between welfare-enhancing public goods and the misallocation of labour and goods induced by government expenditure. Moreover, MEDSEA is extended to allow for some financial market imperfection in the form of financially constrained households. This allows one to capture the negative welfare effects of fiscal consolidation (especially in the form of government expenditure cuts) on credit-constrained households.

Apart from providing a comprehensive documentation of the fiscal extension to MEDSEA, I simulate the model to provide estimates of a number of short-run and long-run fiscal multipliers. Results show that innovations in government consumption have sizeable effects on output that are larger than those pertaining to revenue items at least in the short-run. These effects are however short lived especially in the case of public employment shocks. Government investment shocks have small effects on output in the short-run, especially under a time-to-build scenario, but are consistent with the largest long-run effects on potential output. Similarly, despite having small effects in the short-run, innovations to capital income taxes have the largest long-run effects among revenue items. This is followed by labour income taxes, which however have sizeable effects also in the short-run.

This paper is structured as follows. The next section presents a discussion of the theoretical model. Section 3 presents the calibration of the model, while section 4 presents and discusses the findings of the simulations. Section 5 presents some sensitivity tests while the last section summarises the discussion and tries to elicit some policy recommendations.

2 The Model

This section illustrates the model setup, mainly focusing on the new features introduced in this version of MEDSEA. The basic framework is identical to Rapa (2016). The model therefore contains five types of agents, households, intermediate good producers, final good firms, aggregators and the government. Unlike the original model however, there are two types of households that maximize their lifetime utility over an infinite life horizon.

2.1 Households

The economy is populated by two types of households, I and J. I-type households are referred to as Ricardian or optimising households and are indexed by by $i \in [0, (i-\omega)]$. J-type households are non-Ricardian and are indexed by $j \in [(i-\omega), \omega]$. Optimising households have unrestricted access to financial markets, where they can trade in domestic government bonds and internationally traded bonds and can accumulate physical capital and rent their services to firms. J-type households are liquidity constrained and are not able to trade in financial and physical assets and cannot, therefore, intertemporally smooth consumption. Both types of households however supply differentiated labour and act as wage setters in monopolistically competitive markets.

2.1.1 I-type households

Optimising households derive utility from a consumption bundle $C_t(i)$ relative to a consumption habit $H_t(i)$ defined as a proportion of the households consumption in the previous period, $\chi C_{(t-1)}(i)$, and from leisure $1-N_t(i)$, where $N_t(i)$ is the amount of labour supplied by household (i). Lifetime utility is thus characterised by the following function:

$$E_0 \sum_{(t=0)}^{\infty} \beta^t U_t(i) = E_0 \sum_{(t=0)}^{\infty} \beta^t \{\epsilon_t^c (1-\chi) \ln[C_t(i) - H_t(i)] - \frac{1}{1+\eta} N_t(i)^{1+\eta}\} \tag{1}$$

Where $\beta \in (0,1)$ is the discount factor, ϵ_t^c represents a general shock to preferences that affects the intertemporal elasticity of substitution of households, η is the inverse of the elasticity of work relative to the real wage and $(0 \leq \chi \leq 1)$ measures the degree of external habit formation.

In line with Forni et al. (2010) I define the consumption bundle $C_t(i)$ by:

$$C_t(i) = \left[\phi^{\frac{1}{\nu}} {C_t^P}^{\frac{\nu-1}{\nu}} + (1-\phi)^{\frac{1}{\nu}} {Y_t^G}^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}} \tag{2}$$

where $\nu > 0$ measures the degree of substitutability between private consumption C_t^P and public goods Y_t^G. $(0 \leq \phi \leq 1)$ is the weight of private goods in the consumption bundle. In the special case when $\phi = 1$, government consumption does not directly alter private consumption decisions.

The budget constraint of agent i expressed in units of private consumption is given by:

$$\frac{B_t^G(i)}{R_t^G P_t^C} + \frac{B_t(i)}{R_t P_t^C} = \frac{B_{t-1}^G(i)}{P_t^C} + \frac{B_{t-1}(i)}{P_t^C} + (1-\tau^l)\frac{W(i)N_t(i)}{P_t^C} + (1-\tau^k)\frac{(R_t^K K_t^P(i) + Div_t(i))}{P_t^C} + \frac{TR_t(i)}{P_t^C} - \frac{T_t(i)}{P_t^C} - (1+\tau^c)C_t(i)^P - \frac{P_t^I}{P_t^C} I_t^P(i) \quad (3)$$

Agents can hold 1 period international bonds B_t and government bonds B_t^G that earn a (gross) rate of R_t (controlled by the monetary authority of the euro area) and R_t^G (which in this model is identical to R_t). I assume that Ricardian households own all firms and are thus entitled to a dividend payment $Div_t(i)$. I_t is an investment bundle in physical capital and P_t^I is its associated price which is different from that of consumption P_t^C due to different compositions. Ricardian households receive lump-sum transfers, $TR_t(i)$ from the government and pay lump-sum taxes $T_t(i)$. I-type households accumulate physical private capital K_t^P and rent it to firms at the rate R_t^K. Private capital stock follows the following law of motion:

$$K_t^P = (1-\delta)K_{t-1}^P - I_t + \frac{1}{2}\Psi\left(\frac{I_t}{I_{t-1}}\right)^2 \quad (4)$$

I-type households maximise equation (1) subject to the consumption bundle (2), the budget constraint (3) and the capital accumulation function (4). This yields the following first order conditions with respect to $C_t^P(j)$, $B_t(j)$, $B_t^G(j)$, $I_t(j)$ and $K_t^P(j)$:

$$\lambda_t(i)(1+\tau^c) = \frac{(1-\chi)}{C_t(i)-\chi C_{t-1}(i)}\left(\phi\frac{C_t(i)}{C_t^P(i)}\right)^{\frac{1}{\nu}} \tag{5}$$

$$\lambda_t(i) = \beta R_t E_0\left[\frac{\lambda_{(t+1)}(i)}{\pi^c_{(t+1)}}\right] \tag{6}$$

$$\lambda_t(i) = \beta R^G_t E_0\left[\frac{\lambda_{(t+1)}(i)}{\pi^c_{(t+1)}}\right] \tag{7}$$

$$\begin{aligned} P^I_t =& Q_t\left\{1 - S^I\left(\frac{I_t(i)}{I_{(t-1)}(i)}\right) - S^{I\prime}\left(\frac{I_t(i)}{I_{(t-1)}(i)}\right)\left(\frac{I_t(i)}{I_{(t-1)(i)}}\right)\right\} + \\ & \beta E_0\left[Q_{(t+1)}\frac{\lambda_{(t+1)}(i)}{\lambda_t(i)}S^{I\prime}\left(\frac{I_{(t+1)}(i)}{I_(t)(i)}\right)\left(\frac{I_{(t+1)}(i)}{I_(t)(i)}\right)\right] \end{aligned} \tag{8}$$

$$P^K_t = \beta E_0\left[\left(\frac{\lambda_{(t+1)}(i)}{\lambda_t(i)}\right)\left\{(1-\delta)P^K_{(t+1)} + (1-\tau^k_t)R^K_{(t+1)}\right\}\right] \tag{9}$$

where λ_t is the Lagrangian multiplier associated with the real household budget constraint, Q_t is Tobin's Q which is equal to P^K_t, the implicit price of capital.

2.1.2 J-type households

Liquidity constrained households have the same preferences as optimizing household, represented by equation 1, with $i = j$. J-type households do not own capital or firms and have no access to financial markets. They therefore consume their after-tax wage disposable income plus government transfers. In line with Coenen et al. (2013), I allow for a possible uneven distribution of government transfers amongst Ricardian and Non-Ricardian households. Their real budget constraint is therefore given by:

$$(1+\tau^c)C_t(j) = (1-\tau^l)\frac{W_t(j)N_t(j)}{P^C_t} + \frac{TR_t(j)}{P^C_t} - \frac{T_t(j)}{P^C_t} \tag{10}$$

These households choose private consumption $C^P_t(j)$ to maximize utility, yielding the following FOC.

$$\lambda_t(j)(1+\tau^c) = \frac{(1-\chi)}{C_t(j)-\chi C_{t-1}(j)}\left(\phi\frac{C(j)}{C^P_t(j)}\right)^{\frac{1}{\nu}} \tag{11}$$

2.2 Wage setting

I assume that wages are set by monopolistic unions following the approaches in Gali et al. (2007) and Papageorgiou (2014). Households supply differentiated labour supply to $h \in [0,1]$ unions, each of which represents a type of worker. Each union in turn represents ω I-type households and $(1-\omega)$ J-type households. In each period the union sets the wage of its workers by trading off utility value of labour income with disutility of total work effort taking as given the demand for each labour type h. I assume that the unions allocate labour demand uniformly, independently of them being Ricardian or non-Ricardian, so that $N_t(j) \equiv N_t(i) \equiv N_t$. I assume that unions set a unique wage for both private and public sectors, taking in consideration hours worked in both sectors. I further assume that labour demand is allocated uniformly in each sector such that $N_t^P(j) \equiv N_t^P(i) \equiv N_t^P$ and $N_t^G(j) \equiv N_t^G(i) \equiv N_t^G$.

Thus, unions choose the wage rate W_t in order to maximise the following objective function:

$$L_w = \omega\left[\lambda_t(i)(1-\tau_l)W_t N_t(i)\right] + (1-\omega)\left[\lambda_t(j)(1-\tau_l)W_t N_t(j)\right] \tag{12}$$

subject to a downward sloping demand curve for labour derived from labour aggregators that aggregate labour of types (j) across $j \in (0,1)$ and subject to the definition of total employment.

$$N_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\varepsilon_t^W} \tag{13}$$

$$N_t = N_t^P + N_t^G \tag{14}$$

where $\varepsilon > 1$ is the elasticity of substitution between various labour types.

$\lambda_t(j)$ and $\lambda_t(i)$ in equation (13) are the shadow prices of income for J and I-type households respectively and are used as weights that convert labour income $W_t N_t(j)$ and $W_t N_t(i)$ into household utility. Thus by maximizing equation (12), unions will be trading off the utility derived from labour income with the disutility from labour.

Maximizing the above problem and imposing symmetry, we get the following FOC that pins down the optimal wage chosen by unions:

$$\tilde{W}_t\left(\frac{\omega}{N_t^{\eta}}(1-\tau_l)\lambda_t^{NR}+\frac{(1-\omega)}{N_t^{\eta}}(1-\tau_l)\lambda_t^{R}\right)=\frac{\varepsilon_t^W}{\varepsilon_t^W-1} \tag{15}$$

where $\tilde{W}_t$ is the optimal wage rate demanded by the union. Moreover, $\frac{N_t^{\eta}}{(1-\tau_l)\lambda_t^N R}$ and $\frac{N_t^{\eta}}{(1-\tau_l)\lambda_t^N R}$ are respectively the marginal rates of substitution between consumption and leisure for Type I and J households.[1] Note that in case of one representative household where ω is set as 0, the above FOC becomes a standard equation whereby wages are set as a mark-up (equal to $\frac{\varepsilon_t^W}{\varepsilon_t^W-1}$) over the marginal rate of substitution between consumption and leisure.

In line with Hall (2005) I introduce rigidities in the labour market by assuming that real wages respond sluggishly as a result of unmodelled imperfections. In line with Papageorgiou (2014), I assume that the wage rate prevailing in the market, (W_t) is a geometric weighted average of the past wage rate and the optimal wage set in equation (15).

$$W_t=(W_{t-1})^{\omega_w}(\tilde{W}_t)^{1-\omega_w} \tag{16}$$

where $0\leq\omega_w\leq 1$ denotes the degree of wage indexation.

2.3 Firms

The production sector is in line with that of Rapa (2016). The model contains three intermediate goods firms, those producing tradable output, non-tradable output and firms responsible for importing goods and services. Both tradable and non-tradable firms (denoted by the superscripts XD and N respectively) produce output using analogous production functions:

$$Y_t^i=A_t^i {K_t^i}^{1-\gamma_i} {N_t^i}^{\gamma_i} {K_t^G}^{\gamma_g} \qquad \text{for} \quad i\in[N,XD] \tag{17}$$

where K_t^G is public capital. In line with Baxter and King (1993) and Elekdag and Muir (2014) I

[1]Note that upon imposing symmetry, we can drop the (i) and (j) subscripts from the shadow price of income for Ricardian and credit-constrained households. In this case I differentiate between the two prices using the superscript N and NR. Thus, $\lambda_t(i)\equiv\lambda_t^R$ and $\lambda_t(j)\equiv\lambda_t^{NR}$.

assume increasing returns on public capital. This implies that an increase in public capital does not only increase the output level directly, but also serves to crowd in private employment and capital by raising their marginal productivity. Tradable producers operate in a perfectly competitive market in both input and output sectors and thus they only face a static problem in which they minimise costs subject to equation (17). In the input market, non-tradable domestically oriented firms also operate in a perfectly competitive market minimising costs subject to their production function. However these firms together with those responsible for importing goods and services operate in monopolistically competitive markets in the output sector. Thus they face a dynamic problem in which they exploit their price setting power by maximising profits subject to downward sloping demand curves (derived from aggregators) and subject to nominal rigidities modelled in line with Rotemberg (1982).

The economy produces five private final goods, private consumption and investment (C_t^P, I_t^P), public sector purchases and investment (G_t, I_t^G) as well as a final export good (X_t). The first four, denoted by superscripts $f \in [C^P, I^P, G, I^G]$ operate in a perfectly competitive structure both on the input and output markets and use similar CES production technologies that combine locally produced non-tradeable goods $Y_t^{f,N}$ with imports $Y_t^{f,M}$, to produce their final good Y_t^f. They therefore choose their final level of production by maximizing profits subject to the following production function:

$$Y_t^f = \left[\alpha_f^{\frac{1}{\eta_f}} Y_t^{fM\,\frac{\eta_f-1}{\eta_f}} + (1-\alpha_f)^{\frac{1}{\eta_f}} Y_t^{fN\,\frac{\eta_f-1}{\eta_f}}\right]^{\frac{\eta_f}{\eta_f-1}} \quad \text{for } f \in [C^P, I^P, G, I^G] \tag{18}$$

where α_f is inversely related to the degree of home bias in preferences and $\eta_f > 0$ measures the elasticity of substitution between domestic and foreign goods. This problem produces the following FOCs:

$$Y_t^{fM} = \alpha_f \left(\frac{P_t^M}{P_t^f}\right)^{-\eta_f} Y_t^f; \qquad Y_t^{fN} = (1-\alpha_f)\left(\frac{P_t^N}{P_t^f}\right)^{-\eta_f} Y_t^f; \quad \text{for } f \in [C^P, I^P, G, I^G] \tag{19}$$

Using equations (18) and (19) and imposing a zero profit condition we derive the aggregate price level for government consumption and investment:

$$P_t^f = \left[\alpha_f P_t^{M\,1-\eta_f} + (1-\alpha_f) P_t^{N\,1-\eta_f}\right]^{\frac{1}{1-\eta_f}} \quad \text{for } f \in [C^P, I^P, G, I^G] \tag{20}$$

Final export good producers face a similar static problem except for the functional form of their production function. To reflect the fact that the import content of exports is usually considered to be irreplaceable by domestic sources, final export goods are produced through a Leontief function. Thus, export good producers combine locally-produced tradable goods Y_t^{XD} with imports Y_t^{XM}, to produce their final good X_t through the following function:

$$X_t = min\left[\frac{Y_t^{XD}}{1-\alpha_X}, \frac{Y_t^{XM}}{\alpha_X}\right] \tag{21}$$

In the output sector, final export good producers operate in a monopolistically competitive market and thus face a dynamic problem similar in nature to that faced by intermediate firms. However, following Corsetti et al. (2008), I assume that export manufacturers require Θ units of distribution services intensive in local non-tradables to deliver their final product to the final consumers.[2] So each firm chooses its wholesale intermediate price P_t^{XW} by maximizing its discounted sum of expected profits subject to nominal rigidities, in line with Rotemberg (1982), and to a sequence of demand constraints derived from aggregators. Export prices faced by foreign agents P_t^X, are then given by a weighted average of whole sale export prices and those of local non-tradables:

$$P_t^X = P_t^{XW} + \Theta P_t^N \tag{22}$$

2.4 Fiscal Policy

On the revenue side, the government levies four types of taxes; a tax on labour (τ_t^l), one on capital and dividends (τ_t^k), one on consumption (τ_t^c) and a lump sum tax (T_t) and issues government bonds (B_t^G) on the local market.[3] These are used to finance government investment

[2] For a more complete discussion of the production setup the reader is referred to Rapa (2016).
[3] This assumption is based on the fact that virtually all government debt is owned by Maltese residents.

(I_t^G), government transfers to both types of households (TR_t), government purchases (G_t) and government employment ($W_t N_t^G$) . Moreover, the government pays interest payments (R_t^G) on its local debt. Thus, the government budget constraint expressed in consumption units at time t is:

$$\left[\frac{B_{t+1}^G}{R_t^G P_t^C} - \frac{B_t^G}{P_t^C}\right] + \tau_t^c C_t^P + \tau_t^l \frac{W_t N_t}{P_t^C} + \tau_t^k \frac{(R_t^K K_t^P + Div_t)}{P_t^C} + \frac{T_t}{P_t^C} = \frac{P_t^G}{P_t^C} G_t + \frac{W_t N_t^G}{P_t^C} + \frac{P_t^I}{P_t^C} I_t^G + \frac{TR_t}{P_t^C} \quad (23)$$

I follow Forni et al. (2010) and assume that the government first purchases goods and services (G_t) from local aggregators (who in turn combine both domestic and imported production) and subsequently employs public workers (N_t^G) at the wage prevailing on the market and combines them with public buildings and land (BL_t) to produce public goods (Y_t^G) using the following Cobb Douglas production function:

$$Y_t^G = A_t^G \overline{BL}_t^{(\gamma_{bl})} \left(G_t^{((1-\gamma_{ng}))} N_t^{G(\gamma_{ng})} \right)^{(1-\gamma_{bl})} \quad (24)$$

where $0 < \gamma_{bl} < 1$ is the weight of public buildings in the production of public goods.[4] Moreover, $0 < \gamma_{ng} < 1$ is the weight of government employment in public consumption. All factors of production of public goods are exogenously given, with G_t and N_t^G featuring as government instruments that can be changed through fiscal policy.

The model distinguishes between recurrent public expenditure and government investment. The latter is modelled in a time-to-build setup in line with Kydland and Prescott (1982) and Leeper et al. (2009). This modelling strategy is designed to capture the fact that most public capital projects are subject to implementation delays often dictated by long processes involving planning, bidding, contracting and construction stages. As can be inferred from the results of this study, implementation delays for government investment are important as they may lead to positive wealth effects that dominate the negative wealth effects that are usually associated with government purchases, leading to different private consumption, investment, work effort

[4]Thus $(1 - \gamma_{bl})$ is the weight of public consumption in the production of public goods.

and output dynamics in the short-run following a shock to government investment.[5]

Let IP_t^G be planned or authorised government investment outlays. Once a project is authorised by parliament, it may take a number of quarters, defined as N, till it is finalised and ready to contribute to the production side of the economy. Implemented government investment is then given by:

$$I_t^G = \sum_{n=0}^{N} \phi_{i,n} IP_t^G \qquad \text{where} \sum_{n=0}^{N} \phi_{i,n} = 1 \tag{25}$$

It is only government investment that has been completed (I_t^G) that increase the stock of public sector capital (K_t^G) through the following law of motion:

$$K_{t+1}^G = (1-\delta)K_t^G + I_t^G \tag{26}$$

where $0 < \delta < 1$ is the depreciation rate on public sector capital which is assumed to be equal to that in the private sector.

In line with Forni et al. (2010), I assume that the government can use a unique fiscal instrument i_t to ensure fiscal solvency:

$$\frac{i_t}{i_{t-1}} = \left(\frac{b_t}{b^*}\right)^{\phi_{g1}} \left(\frac{b_t}{b_{t-1}}\right)^{\phi_{g2}} \left(\frac{Y_t}{Y_{t-1}}\right)^{\phi_{g3}} \tag{27}$$

The fiscal rule is designed to bring the government debt to GDP ratio in line with its target b^*. Moreover the fiscal rule reacts with weight ϕ_{g2} to a change in the debt ratio. This ensures a smooth transition of government debt to its target. The fiscal rule also allows for an element of automatic fiscal stabilizers that are responsive to changes in real output.[6] Moreover, the rule is able to consider alternative instruments among four tax instruments ($\tau_t^l, \tau_t^k, \tau_t^c, TAX_t$) and four expenditure items (G_t, N_t^G, TR_t, I_t^G).

[5]For a more detailed treatment of these topics, the reader is referred to Leeper et al. (2009)

[6]If for instance output at time t is lower than in time $(t-1)$, the government will either increase its expenditure on benefits or reduce his tax revenue to help stabilise output.

2.5 Market clearing and aggregation

All household specific variables $X_t(h)$ are expressed in per capita terms to take in consideration the existence of two types of households. Thus $X_t = \int_0^1 X_t(h)dh = \omega C_t(j) + (1-\omega)C_t(i)$. Note that since in equilibrium all individuals of both household types will behave symmetrically, I can drop the (j) and (i) subscripts.[7] Thus per-capita household variables will be expressed:

$$C_t^P = \omega C_t^{P,NR} + (1-\omega)C_t^{P,R} \tag{28}$$

$$K_t^P = (1-\omega)K_t^{P,R} \tag{29}$$

$$I_t^P = (1-\omega)I_t^{P,R} \tag{30}$$

$$Div = (1-\omega)Div^R \tag{31}$$

$$B_t = (1-\omega)B_t^R \tag{32}$$

$$B_t^G = (1-\omega)B^{G,R} \tag{33}$$

$$TR_t = \omega TR_t^{NR} + (1-\omega)TR_T^R \tag{34}$$

$$TAX_t = \omega TAX_t^{NR} + (1-\omega)TAX_T^R \tag{35}$$

Moreover, I allow government transfers and lump sum taxes to be allocated differently across different types of households according to the following rules: $TR_t^R = \upsilon_{TR} TR_t$ and $TAX_t^R = \upsilon_T TAX_t$ where $0 \leq \upsilon_{TR} \leq \frac{1}{(1-\omega)}$ and $0 \leq \upsilon_T \leq \frac{1}{(1-\omega)}$.

Imposing equilibrium in all product markets implies we can derive the following identities:

$$Y_t^N = C_t^D + I_t^{PD} + I_t^{GD} + G_t^D \tag{36}$$

$$Y_t^P = Y_t^N + Y_t^{XD} \tag{37}$$

where Y_t^{XD} is the supply of locally produced export goods. Following Forni et al. (2010), GDP is defined as the sum of private sector production (Y_t^P) and the gross real government wage bill

[7] I then differentiate between variables relating to Ricardian and non-Ricardian households through the superscripts R and NR respectively.

$\frac{(W_t N_t^G)}{P_t^C}$. So GDP is given by:

$$Y_t^R = Y_t^P + \frac{(W_t N_t^G)}{P_t^C} \tag{38}$$

3 Calibration

The calibration of the core part of the model is in line with Rapa (2016). The model is calibrated at a quarterly frequency. Parameters meant to pin down the steady state ratios are calibrated so as to match the observed great ratios in Malta using long-run averages (between 2000-2015) observed from the national accounts statistics. Most parameters that govern the dynamics of the model are calibrated consistently with existing DSGE literature on the euro area and Malta[8] as well as using some microdata studies specific to the Maltese economy.

The discount rate β is set to be consistent with 3% annualised interest rates, while the habit persistence parameter χ, is set to 0.6. The inverse elasticity of labour with respect to real wages is set to 2, in line with the calibration in Coenen et al. (2012) and with the estimation results of Forni et al. (2009) and Smets and Wouters (2007).

Unfortunately, there is no empirical evidence for Malta that can be used to calibrate the parameters governing the way public goods enter the utility function of households. The standard assumption used in DSGE literature[9] predicts that public goods do not directly affect the welfare of agents, implicitly regarding government public expenditure as "complete waste". However, Feve et al. (2013) show that restricting a model to disregard possible welfare effects of public goods, can lead to biases in the estimation of fiscal multipliers, especially with regards to private consumption multipliers. Indeed, estimation of unrestricted models, such as those of Feve et al. (2013) and Ercolani and Valle e Azevedo (2014) provide strong evidence that government expenditure produces externalities that directly affect households' welfare. Estimations of unrestricted models however, have highlighted difficulties in pinning down whether the private and public consumption bundles are complements or substitutes. Feve et al. (2013) as well as Coenen et al. (2013) find evidence that public goods exert positive externalities on private consumption. On

[8]See for instance Micallef (2013).
[9]For example see the models used in Kilponen et al. (2015) as well as Forni et al. (2009).

the other hand, Ercolani and Valle e Azevedo (2014) find evidence that the two are very strong substitutes.

In view of this conflicting evidence I choose a baseline calibration that allows me to refrain from posing a judgement on the elasticity of substitution between private and public goods. Thus I set ϕ to 1, thus disregarding any substitution or complementary effects public goods might have on private consumption. In the sensitivity analysis, I then relax this assumption by setting ϕ to 0.8. In this case I provide two scenarios, one in which the two goods are substitutes (thus following Ercolani and Valle e Azevedo (2014), and one in which they are complements (in line with the evidence of Coenen et al. (2013).[10].

The calibration of firm production technologies, (found in the second part of Table 1) is identical to that found in Rapa (2016), with the labour share in domestic and foreign oriented production, γ_{ND} and γ_{XD}, set to 0.6 and 0.65 respectively, lower than the values usually found in other euro area economies. In the production function for public goods, the share of public buildings γ_{bl} is set at 0.5, in line with Forni et al. (2010) . The labour share in government consumption γ_{ng} is set at 0.7, in line with the actual share of the government wage bill in its consumption. The quasi-shares of intermediate imports in the production of final goods $(1 - \alpha_f)$ for $f \in [C^P, I^P, G, I^G]$ were calibrated such that the model's steady-state matches real-world shares as estimated using the recently published Input Output tables for Malta.[11].

Mark-ups are calibrated in line with Borg (2009) who estimates mark-up values in a number of Maltese markets. Rotemberg parameters capturing the degree of price rigidities are set to be consistent with an annual re-optimisation frequency in line with evidence published in Micallef and Caruana (2014). The wage indexation parameter (ι_w) responsible for introducing nominal wage rigidities was calibrated to 0.95. This calibration was found to keep the responsiveness of real wages following standard shocks roughly in line to those exhibited in Rapa (2016).[12]

With regards to the fiscal variables, these are calibrated using Quarterly Accounts of General

[10]The choice of setting ϕ to 1 in the baseline specification is also justified by the fact this specification is consistent with a first year positive reaction of private consumption following a shock to public consumption, which is in line with the results documented in Borg (2014).

[11]Note that due to lack of data, the share of imports in the production of public investment was assumed to be equal to that of private investment.

[12]Rapa (2016) models nominal wage rigidities in line with Rotemberg (1982). On the other hand the fiscal version of MEDSEA drops the Rotemberg method in favour of the more parsimonious Hall (2005) method. The indexation parameter in the latter method was then set so as to keep the dynamics exhibited by real wages in line with those exhibited in the earlier version of MEDSEA, which had its nominal wage rigidities parameters set consistently with an annual re-optimisation frequency.

Table 1: Steady-state values

DOMESTIC PRIVATE DEMAND	
Private consumption (C^P)	61
Private investment (I^P)	16.4
Exports (X)	106.4
Imports (M)	106
FISCAL VARIABLES	
Public purchases (G)	5.8
Public investment (I^G)	3.4
Transfers to households (TR)	15
Wage bill ($N^G W$)	13.3
Total Expenditure	35.9
Debt (annualised)	60
Effective tax rates	
Labour (τ_l)	27
Rental rate of capital (τ_k)	10
Consumption (τ_c)	22

All ratios with the exception of effective tax rates are expressed in terms of GDP. Effective taxes are expressed as a % of its base.

Government and National Accounts data, in line with the strategy employed in Grech and Rapa (2016). On the revenue side, tax rates are calibrated in line with effective tax rates. The latter were estimated using data found in the Quarterly Accounts of General Government and in the database of STREAM, the central bank of Malta's macroeconometric model.[13] The tax rate on wage income (τ^l) is set to 27%, the tax rate on physical capital and firm profits (τ^k) to 10% and the tax rate on consumption (τ^c) to 22%.

On the expenditure side, both data from the Quarterly Accounts of General Government and National Accounts were used.[14] Government purchases of goods and services, transfers to households, government investment and the public sector wage bill were all calibrated as a ratio to

[13] See Grech and Rapa (2016) for more information.

[14] Data from the Quarterly Accounts of General Government are required because they correspond to key fiscal statistics, such as the government balance and government debt, while data from the National Accounts are needed to generate a series of government consumption that is consistent with GDP data. See Grech (2014) for more information on the data sources.

GDP. Since the steady-state for some of these expenditure items (mainly government investment and government purchases of goods and services) can be set exogenously, the model is able to perfectly match actual data. With regards to the pubic sector wage bill, only one of the two components making up this item, public employment, is exogenously set while the other, wages, is endogenously set by the model. In this light, I choose to change public sector employment (at the cost of being unable to match the share of public sector employment to total employment) in order to match the model's government wage bill with actual data. Thus the ratio of overall government consumption (which in this model is defined as the sum of government purchases and public sector wage bill) to output is perfectly matched by actual data. A similar point is valid with regards to interest expenditure on government debt. Interest payments depend on both government debt and interest rates. The former is set to 60% in steady state, which is the maximum long-run level of debt permitted under the Stability and Growth Pact. Interest rates, on the other hand, are set endogenously by the model. For these reasons the model does not perfectly match actual government expenditure on interest payments found in the data. This notwithstanding, the model's overall government expenditure to output ratio in steady state stands at 36%, which is still relatively close to the actual government expenditure ratio of 39%.

The parameters of the fiscal rule that govern the responsiveness of the fiscal instrument follow Forni et al. (2010). Therefore, I set ϕ_{g1} to 1.5 and ϕ_{g2} and ϕ_{g3} to 15. The signs of these parameters are positive when the fiscal policy is defined in terms of a revenue item of the government, but negative in case the fiscal instrument in use is an expenditure item.

4 Results

This section provides estimates for a number of short and long-run fiscal multipliers. In the latter case I also allow for different short-run and long-run effects of fiscal policy changes depending on the instrument used to stabilise the government debt ratio. All simulations are performed under perfect foresight, thus assuming that fiscal paths are fully anticipated by agents ruling out any uncertainty relating to the path of fiscal variables.[15]

In all simulations considered in this section, I assume either a temporary or a permanent contrac-

[15]The transmission mechanism of fiscal shocks can be seen more clearly in Appendix B, which includes the impulse responses of specific variables of interest following a very temporary but persistent shock in all fiscal instruments.

tionary fiscal shock in one specific instrument amounting to 1% of baseline GDP. All remaining fiscal instruments are held constant for the first two years after the simulation starts. From then onward one of these fiscal instruments is allowed to adjust in order to stabilise the public debt to GDP ratio at its target long-run value. In case of permanent shocks, the multipliers will be sensitive to the fiscal instrument used in the policy rule[16]. I thus conduct these simulations using two different adjusting instruments. For both temporary and permanent shocks I show results for a set of five short-term fiscal multipliers pertaining to two expenditure items: government consumption (consisting of shocks to government purchases and public wage bill) and government investment, and three taxation shocks: income tax, consumption tax and capital tax.

4.1 Short-Run multipliers

4.1.1 Government Expenditure

Table 3 shows that multiplier results for all temporary fiscal shocks are less than one throughout the two year period under consideration. In the case of the government expenditure shocks, this implies that following the shock, the crowding-in effect of the private sector partially offsets for the reduction in public expenditure.

Government Consumption

Following a fall in government consumption[17], employment demand diminishes both directly due to the shock to government sector wage bill and indirectly via the reduction in the demand of domestic production. This leads to a reduction in real wage pressures leading to negative income effects. In case of Ricardian households, this only partially offsets the positive wealth effect resulting from the expectations of lower taxes associated with lower government spending. In light of the higher positive wealth effect, private consumption and private investment increase slightly following the shock. Since credit-constrained consumers are unable to smooth consumption, they do not benefit from the positive wealth effect. This implies that these types of households reduce

[16]In case of transitory shocks, multiplier results are affected only modestly by the choice of the fiscal variable included in the fiscal rule

[17]The shock to government consumption is conducted as a shock to government purchases and to the government wage bill. The shocks are calibrated so that these items retain their original share in total government consumption.

their private consumption with per-capita private consumption falling slightly in the first year after the shock. The reduction in real wages transmits to the rest of the economy via lower real marginal costs leading to a slight improvement in external sector competitiveness and in turn resulting in a slight increase in exports. This offsets somehow (especially by the second year of the simulation) the negative output effects stemming from the domestic sector. The reduction in real wages also translates into slightly lower inflation. In view of the small open economy assumption this does not lead to a reduction in nominal interest rates leading to higher real rates which produce negative substitution effects that partially offset the positive Ricardian consumer wealth effects.

Table 2: Short-run fiscal output multipliers

	Year 1	Year 2
Government consumption	-0.53	-0.19
Government purchases	-0.31	-0.20
Government wage bill	-0.61	-0.18
Government investment	-0.57	-0.96
Labour Tax	-0.17	-0.29
Consumption Tax	-0.25	-0.22
Capital Tax	-0.03	-0.08

Results follow temporary fiscal shocks normalised to 1% of steady-state output. Multipliers are computed as annual averages in % deviation of output from its initial steady-state.

It is interesting to note that the short-run multipliers pertaining to government consumption shocks are smaller than those reported in existing literature for Malta.[18] Estimates from STREAM (Grech and Rapa, 2016) and EAGLE (Micallef, 2013) indicate that following a 1% fall in government consumption, output is expected to fall by 0.78% and 0.73% respectively compared to a fall of 0.53% estimated in this analysis. This divergence is even more pronounced when comparing to VAR evidence published in Borg (2014) which estimates an output multiplier for the first year equal to 0.99. Differences between the results of this model and those of Borg (2014) may stem from differences in the way the simulations are conducted. In line with DSGE literature, the government consumption shock is performed by shocking government consumption elements by 1% of steady state output while maintaining all other fiscal instru-

[18]See Borg et al. (2015) for a comprehensive summary of fiscal multiplier literature for the Maltese economy.

ments constant for two years. On the other hand the government consumption shock identified in Borg (2014) is consistent with a significant contemporaneous fall in net taxes that moves the government balance further into negative territory, thereby enhancing the negative response of output following this shock.

The divergences between estimates in STREAM and MEDSEA are mostly related to the fact that the former model is completely backward looking and therefore excludes positive wealth effects accruing from a reduction in future taxes to be paid by households following a contractionary fiscal shock. Moreover, the STREAM model is unable to capture the distortionary effects public consumption is likely to have on household's optimal private consumption choices. This implies that the model is bound to overestimate the effects of government consumption shocks. Discrepancies between results of MEDSEA and the EAGLE models can be explained by two factors. First, EAGLE assumes that government consumption is made up entirely of local intermediate production, in essence assuming no import content. However, input-output data suggests that more than 60% of non-wage government consumption is directly imported. Secondly, EAGLE makes no distinction between the wage component of government consumption and that made up of government purchases of goods and services. Thus, the estimates of EAGLE in Borg et al. (2015) do not take into consideration that a fall in government employment (directly driven by the shock in government consumption) is likely to reduce labour demand, thus reducing real wage and crowding in private labour. This is in turn likely to boost private sector employment leading to positive income effects.

Given the detailed structure of the fiscal block in MEDSEA, I can disaggregate the effects of a government consumption shock into those pertaining to a shock in government purchases of goods and services and a shock to the government wage bill. The effects of the two shocks differ both in terms of magnitude and their propagation to the rest of the economy. To see this, I redefine the government consumption shock as a shock to either government purchases only or to the government wage bill, both normalised to be equivalent to 1% of GDP ex ante. The reduction in government purchases creates a smaller but more persistent fall in output than an equivalent drop in the government wage bill. This is mainly driven by two factors. First, government purchases contain a substantial proportion of import content implying that less than 40% of the overall impact on government consumption is directly leading to an increase in local production of goods and services. On the other hand, the full magnitude of a shock to the government wage gets transmitted in overall GDP. However, even in this case, the short-run multiplier is much smaller than 1 implying that the inefficiencies associated with fiscal distortions are substantial.

Secondly, the reduction in the government wage bill directly releases labour effort which is now employable by the more productive private sector. The lower demand for labour effort leads to a fall in real wages which transmits to the rest of the economy leading to an improvement in external competitiveness thus increasing demand for Maltese exports. Moreover, the expectations of lower future taxes create a wealth effect that increase per capita consumption and investment. Lower wages also lead private firms to increase their own demand for labour increasing private production. Indeed, contrary to the case of a shock to government expenditure, a government wage bill shock is accompanied by a rise in private sector output. These positive effects are however still not enough to make up for the direct negative effects a fall in the government wage bill has on total output, implying that the total output multiplier is still negative by the second year after the shock. On the other hand, the shock to government expenditure affects labour supply in an indirect and less significant way, leading to a much lower fall in real wages. This implies that the gain in external competitiveness and thus the increase in Maltese exports are considerably lower in the case of a shock to government expenditure on goods and services leading to a more persistent fall in overall output.

Government Investment

In contrast to a negative government consumption shock, a decline in public investment[19] creates a stronger and more persistent effect on total output suggesting that fiscal consolidation strategies based on reductions in government investment are in general more costly to the economy. A decline in government investment reduces the government stock of capital which directly decreases product and service supply. Moreover, the reduction in government stock also reduces the marginal productivity of the other inputs, crowding out private labour and capital creating additional supply responses that further contribute to the fall in GDP. Moreover, lower productivity creates a negative wealth effect that drives consumers to reduce their private consumption. Despite a fall in aggregate demand the response of inflation is still positive, driven by the restriction of total supply following the shock. This translates into higher marginal costs to local intermediate producers that translate into higher export costs and thus consequently into lower exports.

[19] For the time being I will deal with government investment shocks under the assumption of no implementation delays. These effects will be dealt with when looking into long-run multipliers.

4.1.2 Government Revenue

The last three multipliers in Table 2 show results for short term tax multipliers. In general, and in line with literature[20], results for tax multipliers are lower than those pertaining to expenditure items, especially in the first year of the simulations.

Labour Income Taxes

A rise in the rate of labour tax, reduces real after tax wages. This has two distinct effects. First, a negative income effect (which outweighs the effects of positive wealth effects related to the expectations of lower taxes in the future) reduces aggregate demand as both types of households reduce private consumption. Secondly, the reduction in after tax real wages also raises the marginal rate of substitution between consumption and leisure driving households to reduce labour effort for a given pre-tax real wage. On the other hand, reductions in final aggregate demand lower demand for labour somewhat. However the latter effects are smaller prompting firms to increase real wages in an effort to increase supply of labour hours. This drives real marginal costs up, leading to some inflationary pressures that reduce Malta's external competitiveness, prompting a fall in exports. In view of wage and price rigidities, these effects are slow to materialise implying that unlike the effects of a fall in government consumption, those pertaining to a labour tax hike, peak in the second year after the start of the simulation.

Private Consumption Taxes

Unlike the output effects following an income tax hike, those following a consumption tax increase peak in the first year after the start of the simulation. Following the increase in consumption taxes, gross inflation experiences a one-off increase. A reduction in the purchasing power of households' disposable income leads to a negative wealth effect that leads both Ricardian and credit-constrained consumers to reduce private consumption, leading to a reduction in aggregate demand and demand for factors of production. This reduces real wages, again creating negative income effects that further restrain per capita private consumption. As households reduce private consumption more resources are shifted towards higher private investment, which rises notwithstanding a reduction in aggregate demand. Moreover, reductions in real wages lead to

[20]See for instance Kilponen et al. (2015) for a comparison of fiscal multiplier estimates across different models

lower marginal costs that lead to a somewhat contained improvement in Malta's competitiveness, increasing demand for exports, especially in the second year of the simulation. However, despite increases in private investment and exports, the overall impact on GDP remains negative throughout the first two years of the simulation.

Capital Income Taxes

A rise in capital income taxes creates a negative wealth effect as households anticipate lower returns from their capital holdings. This causes a somewhat contained reduction in the consumption of Ricardian households. Moreover, the reduction in after-tax return on capital leads firms to diversify away from capital and choose a more labour intensive capital-labour mix. Despite becoming relatively cheaper, labour effort does not increase in the economy, as reductions in aggregate demand weigh negatively on factor demands. Moreover, higher prices for investment start to raise the real marginal costs of intermediary firms leading to some inflationary pressures by the end of the simulation. This leads to a worsening of Malta's international competitiveness leading to lower demand for exports, weighing negatively on overall GDP.

Government revenue multipliers are slightly lower than the SVAR estimates in Borg (2014), but are slightly higher than those derived from other structural and semi-structural models in Borg et al. (2015). Almost all tax multiplier results are however lower than those derived through the New Area Wide Model for the euro area. The only exception are the results pertaining to labour taxes, which are slightly higher than those for the euro area, but in line and in some cases even smaller than those for other small open economies such as Estonia, Portugal and Greece. In line with estimates derived from EAGLE, capital tax multipliers are relatively small when compared to other euro area economies. This most likely reflects the fact that Malta has one of the lowest effective capital tax rates in the euro area, implying that a shock in capital income taxes creates relatively low distortionary effects.[21]

Table 3: Long-run fiscal output multipliers

	Adjusting TAX_t				Adjusting τ_t^l			
	Year 1	Year 2	LR	$\frac{TAX_t}{\overline{Y}}$	Year 1	Year 2	LR	$\frac{\tau_t^l N_t W_t}{\overline{Y}}$
Government consumption	-0.45	-0.11	0.06	-0.98	-0.42	-0.05	1.07	-1.25
Government purchases	-0.21	-0.14	-0.49	-1.23	-0.06	-0.03	0.48	-1.13
Government wage bill	-0.57	-0.10	0.33	-0.92	-0.53	-0.05	1.28	-1.26
Govt. investment	-0.61	-0.98	-4.50	-1.76	-0.38	-0.83	-3.00	-1.85
Govt. investment delayed	-0.06	-0.03	-4.49	-1.74	0.16	0.05	-3.00	-1.85
Labour Tax	-0.29	-0.34	-0.84	-1.04	-	-	-	-
Consumption Tax	-0.19	-0.19	-0.51	-1.15	-0.05	-0.10	0.35	-1.07
Capital Tax	-0.13	-0.21	-1.13	-1.13	0.01	-0.12	-0.16	-1.08

The first three columns of each panel show the first year, second year and long-run multipliers for permanent fiscal shocks normalised to 1% of steady-state output. Multipliers are computed as annual averages in % deviation of output from its initial steady-state. The fourth column of each panel shows the adjustment in percentage point deviations of the fiscal instrument used in the fiscal rule.

4.2 Long-Run multipliers

In this section, I analyse the effects of permanent discretionary shocks to fiscal instruments that permanently alter the fiscal structure of the economy. Similar to the previous section, the fiscal rule is deactivated in the first two years. After the second year it becomes active again in order to ensure fiscal sustainability. However, contrary to the case of temporary shocks, the responses following permanent shocks depend significantly on the fiscal instrument used in the fiscal rule. I thus explore two scenarios; one in which any tax adjustments are carried out via changing lump sum taxes and a second (more plausible) case where fiscal sustainability is guaranteed through variations in the labour tax rate. The adjustment in the government revenue instrument required to stabilise the debt-to-output ratio is showed in the last column of each panel. To aid the comparison between the adjustment required through different fiscal instruments, the government revenue items are first normalised by the steady-state level of output and then expressed as percentage point deviations from steady-state. The long-run adjustment in the fiscal instrument provides valuable insights on the fiscal space created for each shock as

[21] Another factor relates to some modelling choices in MEDSEA. In order to reflect the role FDI plays in supplying capital to export oriented firms, the model assumes that all capital utilised by tradable intermediate firms is owned externally and evolves exogenously to local developments. Thus the negative wealth effect that follows a fall in income taxes is limited to locally owned capital. While in the long-run foreign capital is allowed to move to keep a fixed share of total capital in the economy, the model is likely to underestimate the effects of capital taxes as it is unable to endogenously explain a fall in FDI following an increase in capital taxes.

well as whether (as is the case in this model) stability in the debt ratio is achieved through 'sensible' changes in the fiscal instrument.

4.2.1 Government Expenditure

Government Consumption

The first three columns of Table 3 show multiplier results of a permanent fall in government consumption (calibrated as in section 4.1) with the fiscal rule specified in terms of lump-sum taxes. The estimated short-run multipliers in this case are smaller in absolute terms than those following temporary shocks. This is largely due to a larger positive wealth effect on Ricardian households who expect a permanent reduction in future lump-sum taxes. This, pushes this type of households to increase consumption faster and to a larger extent when compared to a temporary shock. This wealth effect therefore, has a crowding-in effect that increases private consumption and investment. This together with the boost in external competitiveness brought about by a temporary fall in Maltese inflation, help turn the multiplier positive already by the third year after the simulation. The reduction in lump sum taxes occurring from year 3 onwards, boosts private consumption of credit-constrained consumers pushing the overall multiplier deeper into positive territory. Looking at the decomposition of government consumption into its purchases of goods and services and wage bill component, one can note that the lower short term multiplier for the first year is driven by a more muted multiplier of government purchases. In line with their short term counterparts for temporary shocks, those pertaining to permanent shocks, show a relatively weak response in the first year that becomes smaller in the second year. Already by the fourth year after the shock, the output response starts to move deeper into negative territory as real activity starts moving towards its new lower steady state. Results following a permanent reduction in government employment is similar to the results in Table 2. The wealth effects created by the prospect of a permanent reduction in labour distortions however are higher than those consistent with temporary shocks to government labour implying a more positive multiplier already by the 9^{th} quarter of the simulation. Thus the marginally positive long-run multiplier for a reduction in government consumption is wholly driven by the shock in the wage bill component of government consumption. Long-run multipliers for government consumption shocks in EAGLE are, as expected given the lack of a government wages component in public consumption, negative. Results derived from MEDSEA, especially for the separate government purchases and wage bill shocks, are qualitatively in line with those published in Forni et al. (2009) which predict long-run positive effects on output following a reduction in labour income while negative ones following public purchases shocks.

The last three columns of Table 3 show multipliers estimated with a fiscal rule specified in terms of labour taxes. This implies that a fall in government consumption is (in the long-run) compensated by a reduction in labour taxes that in the long run is equivalent to column 4 of this panel. On the contrary of lump-sum taxes, labour taxes are distortionary since they affect the leisure/work-effort trade-off faced by households by introducing a wedge between the wage costs faced by firms and the return on work effort received by households. The prospect of lower labour taxes create a stronger wealth effect than that created by the expectations of lower lump-sum taxes, which induces a stronger (and more prolonged) increase in private consumption by Ricardian households. This causes the short term multipliers to be less negative than in the case a fiscal adjustment done through lump-sum taxes. Moreover, the reduction of labour taxes after the second year, causes a reduction in gross real wages, while at the same time increasing post-tax real wages. This drives firms to increase demand for labour while households gradually choose to increase labour effort. The increase in labour utilisation makes capital more productive leading to a permanently higher private investment. These effects lead to a permanent and large supply-side effect on the economy. On the demand side, the reduction in gross real wages leads to a sustained fall in real marginal costs, resulting in a prolonged fall in local inflation thus further increasing demand for Maltese exports. Both supply and demand side effects lead to a relatively strong positive long-run multiplier of 1.07. In the case of a fiscal rule specified in terms of labour taxes, both components of government consumption contribute to the dynamics of output following a government consumption shock. Both, government purchases and employment shocks contribute negatively in the first two years, with their contribution turning positive already by the 9^{th} and 8^{th} quarter respectively. Albeit being positive, estimates derived from EAGLE (Borg et al., 2015) of long-run multipliers for a government consumption shock financed through changes in labour taxes, are lower than those suggested by MEDSEA. This is to be expected, especially when considering the divergences that exist between the two models when it comes to the treatment and modelling of government consumption.

Government Investment

The short-run multipliers following a permanent shock to public investment with fiscal rule defined in lump-sum taxes, are similar to those presented in section 4.1. The decision to stabilise government debt through a reduction in income tax helps to attenuate at least to some extent the negative repercussions of a reduction in public investment. Indeed in such a case, the short-run multipliers following a fall in public investment are less negative than in the case of lump-sum tax adjustments. However, in the long-run such a policy would still lead to substantial negative effects on overall output. Indeed the effects attributed to a reduction in productivity of both labour and capital inputs which follows a cut in public investment, is expected to outweigh any gains attributed to the reduction in the distortionary effects associated with labour taxes. Thus a permanent cut in government investment is associated with a fall in overall output of around 4.5% in case of lump-sum taxes adjustments and 3% in case fiscal stability is reached via a reduction in labour taxes.

To account for implementation delays in government investment decisions, I re-run the simulations assuming that any investment decisions that are announced by the government take up to five years before they are fully implemented and ready to contribute to the supply side of the economy. This means that a decision to cut investment made at year $t = 1$ will start affecting the public sector capital stock, and therefore the productivity of private sector inputs, at year $t = 6$. Moreover, I assume that even after the implementation delays, government investment will not become productive all at once, implying that the effects on private sector productivity will materialise gradually. This assumption leads to different government investment multipliers in the short-run. After a decision to cut public investment, the economy starts to experience a slowdown in the demand for public investment goods reducing private employment somewhat and creating a negative income effect. In light of the high import content of investment goods, this negative income effect is expected to be quite small. Furthermore, these developments are still not affecting the public sector capital stock implying that the productivity of private sector factors of production is still unchanged. Given the distortionary nature of public expenditure, a reduction in investment goods demanded by the public sector creates a positive wealth effect on Ricardian households who now expect lower taxes in the future.

In the short-run, this positive wealth effect is expected to outweigh any negative effects of lower investment, which in the absence (for the time being) of negative supply side effects, is limited to a small income effect driven by the reduction in the demand of local government investment goods. This implies that in the short-to-medium run Ricardian households increase private consumption. On the other hand, due to their inability to smooth consumption, credit-constrained consumers are only affected by the negative income effect that induces them to reduce consumption sharply.

However, in the short-run both per-capita consumption and private investment are expected to increase. This, however, is not enough to make up for the lower demand for government investment, leading to slightly lower overall output in the first two years of the simulation. As soon as the negative supply side effects start to impinge on the economy, private consumption and investment together with exports and therefore output, fall sharply matching the dynamics and magnitude seen in the previous simulation with no implementation delays. In case that the fiscal space created by lower public investment is used to lower labour taxes, the positive wealth effects seen in the short-run are amplified leading to a more pronounced increase in Ricardian households' consumption and investment, pushing the expected change in output into positive territory. As soon as the negative supply side effects associated with lower public sector capital stock starts to affect the economy, private consumption, investment, exports and output fall in line with the simulations with no time-to-build assumptions.

4.2.2 Government revenue

Labour Income Taxes

The last three rows of table 3 show results for permanent increases in government taxes. Short-run multipliers for a permanent increase in labour tax are more negative than in the case of transitory shocks. This is largely due to a larger permanent income effect associated with the anticipation of permanently lower after-tax real wages that outweighs the positive wealth effects associated with a permanent reduction in lump-sum taxes.

Private Consumption Taxes

Driven by a more muted response of private consumption, the effects of a permanent increase in consumption taxes are less pronounced than those pertaining to a temporary shock. The positive wealth effect associated with a permanent fall in lump sum taxes partly makes up for the negative income effects driven by higher consumption taxes that in essence reduce the purchasing power of all households' disposable income. Thus following a permanent consumption tax shock, Ricardian households reduce private consumption more gradually and to a lower extent when compared to a temporary shock. At -0.51, the long-run multiplier is larger than the short-run multipliers mainly because of the gradual response of private consumption which is also helped by habit formation. The short-run multipliers are lower in absolute terms in the case when the fiscal space created by the hike in consumption taxes is used to permanently reduce taxes on labour. The expectations of permanent falls in labour taxes create a positive wealth effect that compensates for the permanent increase in consumption taxes. In the short-run, this translates into a more subdued fall in private consumption which reduces the impact on total output. After 8 quarters, income taxes start to fall to stabilise the government debt ratio. This causes real after tax wages to increase creating a positive income effect that exerts upward pressures on private consumption of both types of households. The response of consumption of credit-constrained households turns positive immediately after the first cuts in income tax, while the consumption of Ricardian households remains slightly negative throughout the simulation. The fall in the income tax also reduces the marginal rate of substitution between consumption and leisure driving households to increase labour effort. This increase in labour supply reduces gross wages, thereby reducing labour costs for firms and thus leading to favourable trade effects that push the multiplier into positive territory. The results are similar to those in Kilponen et al. (2015) which document lower short term consumption tax multipliers (in absolute terms) when the shock is permanent vis-a-vis to a similar transitory shock. The results of this study also confirm the same authors' findings of a positive output multiplier following a consumption tax shock that is compensated by a fall in labour income taxes.

Capital Income Taxes

Finally, short-run multipliers following a permanent increase in capital taxes are larger in absolute terms than the multipliers that follow a transitory change in the same tax. Ricardian households anticipate that their net return on investment will be permanently lower following this shock. Thus, they start to favour consumption over investment leading to a short-lived and marginal increase in private Ricardian consumption as well as to lower investment which translates into less capital stock available for firms. The reduction in capital makes labour less productive prompting a reduction in labour demand which reduces real wages. This leads to a negative income effect prompting credit-constrained consumers to reduce their private consumption somewhat. All-in-all the effects on total private consumption are marginally negative in the short-run. As lump-sum taxes start to fall, the disposable income of non-Ricardian households starts to climb, prompting an increase in their private consumption. On the other hand, in view of the negative wealth effect driven by a lower return on investment, private consumption of Ricardian households continues to fall. This suggests that increases in capital taxes that are compensated through lump-sum taxes or transfers might have significant asymmetric effects on the wealth distribution within an economy. With time, the effects of lower capital accumulation start to weigh down on the supply side of the economy which translates into higher local inflation that negatively impact Malta's external side. This continues to impinge negatively on the overall effects on output with the long-run multiplier reaching -1.1% at the new steady-state. While being slightly lower in absolute terms, these results are in line with those put forward in Kilponen et al. (2015) for Malta.

Both short and long-run multipliers are lower in absolute terms in the case of a fiscal rule specified in terms of labour taxes. The prospect of lower labour taxes prompts households to increase labour supply, which help attenuate the negative effects on employment brought about by a reduction in labour productivity which follows a reduction in the capital stock utilised by firms. A lower reduction in labour income prompts less negative effects on private consumption of credit-constrained consumers and reinforces the temporary increase in Ricardian household consumption. This effect causes overall output to increase marginally in the first two quarters after the shock. Over time however, the negative wealth effect consistent with a lower net return on investment starts to weigh down on the response of consumption of optimising households, driving it into negative territory after approximately 10 years. The fall in income taxes also helps reduce real gross wages exerting downward pressures on labour costs faced by firms. This helps attenuate the effects of tighter supply side constraints which in turn lead to higher domestic inflation. Still, the overall effects on external trade is significantly negative. All-in-all, the long-run multiplier remains negative implying that the expansionary effects of lower labour taxes compensate only partially for the recessionary effects of a permanently higher capital tax. This conclusion is similar in nature to that put forward for all EA economies by Kilponen et al. (2015).

5 Sensitivity

In this section I perform a set of robustness checks across three important dimensions of the model. First, I relax the simplifying assumption that public goods are simply 'pure waste' by changing the weight ϕ of public goods in the total consumption bundle that enters the household utility function. I then provide results consistent with two scenarios, one in which public and private goods are substitutes and another in which the two goods are complements. Second, I check how the multiplier results vary with the elasticity of labour supply, which drives the response of labour supply to government employment and tax cuts, most notably those on

Table 4: Short-run fiscal multipliers

	Baseline		$\phi = 0.8$, $\nu = 1.5$		$\phi = 0.8$, $\nu = 0.5$		$\eta = 1$		$\omega = 0.2$	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Government consumption	-0.53	-0.19	-0.46	-0.19	-0.55	-0.22	-0.65	-0.41	-0.53	-0.21
Government purchases	-0.31	-0.20	-0.19	-0.15	-0.33	-0.24	-0.33	-0.24	-0.31	-0.20
Government wage bill	-0.61	-0.18	-0.57	-0.20	-0.64	-0.21	-0.78	-0.48	-0.62	-0.21
Govt. investment	-0.57	-0.96	-0.58	-0.99	-0.57	-0.96	-0.60	-1.04	-0.57	-0.96
Labour Tax	-0.17	-0.29	-0.19	-0.31	-0.17	-0.28	-0.18	-0.32	-0.16	-0.31
Consumption Tax	-0.25	-0.22	-0.18	-0.15	-0.17	-0.15	-0.26	-0.26	-0.24	-0.23
Capital Tax	-0.03	-0.08	-0.03	-0.07	-0.03	-0.08	-0.03	-0.09	-0.03	-0.06

Results follow temporary fiscal shocks normalised to 1% of steady-state output. Multipliers are computed as annual averages in % deviation of output from its initial steady-state.

labour income. Lastly, in view of the lack of micro-data that could help pin down the proportion of non-Ricardian households, I vary their weight ω in the model.

As already mentioned in the calibration section, the empirical evidence of the role public goods play in the household utility function is somewhat mixed. In this respect the baseline calibration attempts to remain agnostic on the sign of this effect by calibrating the weight of public goods in the consumption bundle of households, $1 - \phi$, as 0. In this section I relax this assumption and calibrate this weight to 20%. I then provide two scenarios, one that follows the results of Ercolani and Valle e Azevedo (2014); i.e. that private and public goods are substitutes, and another in which the two types of goods are complements, as found Coenen et al. (2013). I thus set ν to 1.5 and 0.5 respectively for these two scenarios. Table 4 shows short-run multiplier consistent with the baseline calibration as well as with the other alternative calibrations.

The first two columns of Table 4, and the first three of Tables 5 and 6 report multiplier results of the baseline model. The third and fourth columns of Table 4 present short-run multipliers consistent with the assumption that public and private goods are substitutes, whereas short-run multipliers in the fifth and sixth columns are consistent with a model that treats public and private goods as complements. Results for almost all of the revenue multipliers are not sensitive to this assumption. The only exception are the multipliers pertaining to a consumption tax shock which become less pronounced in case the consumption bundle entering the household's utility function is made up of both private and public goods. Multiplier results of a government investment shock are also robust to different specifications of the utility function of households. Results following a government consumption shock are on the other hand sensitive to whether public goods enter as substitutes or complements in the household utility function. In the former case, output multiplier results are more subdued, mainly due to a positive substitution effect that boosts private consumption of Ricardian households following a cut in government consumption. In the latter case, results show a slightly more pronounced fall in output, mainly driven by a negative response of private consumption of optimising households. Despite exhibiting a similar pattern, short and long-run multipliers following permanent fiscal shocks (shown from the fourth to the ninth column of Tables 5 and 6), are found to be more robust to changes in the parameterisation of the utility function. This implies that the wealth and income effects that drive the results in the baseline model, outweigh any effects that are introduced by assuming substitutability or complementarity between public and private goods.

Reducing the value of η, leads to a higher elasticity of labour supply, consistent with a more pronounced response of labour supply for a given change in real wages. This in turn implies a lower variation in real wages, as a higher proportion of labour market imbalances will be cleared through changes in the total labour effort supplied in the economy. Given that this model is only able to reflect changes in labour effort that occur at the intensive margin, a low value for η could help mimic the effects of an adjustment in the labour market that happens at the extensive margin. This could be important especially in the light of the recent increases in the Maltese labour supply brought about by increases in the participation rate, as well as by the large inflow of foreign workers that are helping to damped wage increases in spite of the significant skill shortages currently affecting the Maltese market.

Short-run multiplier results following temporary shocks are shown in the seventh and eighth column of Table 4. Most multipliers are robust to changes in the calibrated value of η. The only exception are the multiplier results related to a shock in government consumption, more precisely those related to a change in the government wage bill component. The extra labour supply created by the cut in government employment leads to a a reduction in real wages which is less pronounced than that predicted by the baseline model. This in turn implies a lower fall in real marginal costs faced by firms, and thus a more subdued fall in inflation that drives a lower increase in exports. Since most of the crowding in effect that follows a government consumption shock is driven by an improvement in external competitiveness, a higher labour elasticity is consistent with a smaller dampening effect, thus implying higher government consumption multipliers.

As shown in Table 5, all multipliers for permanent fiscal shocks compensated by increases in lump-sum taxes are more pronounced when labour supply is assumed to be more elastic. It is important to note that unlike the baseline model, this alternative calibration predicts a negative long-run effect on output caused by a reduction in government employment that has been compensated by a long-run fall in lump-sum taxes. Again the main driver behind this result is the increased responsiveness of labour hours that translates into a lower improvement in long-run international competitiveness.

The long-run multiplier results of the baseline calibration are however robust to a different specification of η, when the fiscal space created by the contractionary fiscal policy is used to reduce income taxes. As argued above, a lower value of η is consistent with a higher responsiveness of labour hours to given changes in the real wage, implying higher multipliers in absolute terms in the case of a permanent change in the government's fiscal stance. Under this alternative

Table 5: Long-run fiscal output multipliers - Adjusting TAX_t

	Baseline			$\phi = 0.8$, $\nu = 1.5$			$\phi = 0.8$, $\nu = 0.5$			$\eta = 1$			$\omega = 0.2$		
	Yr 1	Yr 2	LR	Yr 1	Yr 2	LR	Yr 1	Yr 2	LR	Yr 1	Yr 2	LR	Yr 1	Yr 2	LR
Government consumption	-0.45	-0.11	0.06	-0.44	-0.14	-0.01	-0.41	-0.13	0.14	-0.67	-0.39	-0.36	-0.45	-0.14	0.09
Government purchases	-0.21	-0.14	-0.49	-0.08	-0.09	-0.35	-0.20	-0.18	-0.57	-0.28	-0.21	-0.77	-0.18	-0.13	-0.43
Government wage bill	-0.57	-0.10	0.33	-0.56	-0.15	0.38	-0.58	-0.13	0.26	-0.77	-0.45	-0.17	-0.59	-0.14	0.34
Govt. investment	-0.61	-0.98	-4.50	-0.58	-1.00	-4.45	-0.61	-0.98	-4.50	-0.71	-1.11	-4.74	-0.58	-0.97	-4.44
Govt. investment delayed	-0.06	-0.03	-4.49	-0.02	-0.03	-4.45	-0.06	-0.04	-4.50	-0.12	-0.08	-4.74	-0.03	-0.04	-4.44
Labour Tax	-0.29	-0.34	-0.84	-0.30	-0.37	-0.84	-0.29	-0.33	-0.84	-0.40	-0.46	-1.26	-0.28	-0.37	-0.84
Consumption Tax	-0.19	-0.19	-0.51	-0.12	-0.12	-0.30	-0.13	-0.13	-0.36	-0.25	-0.26	-0.76	-0.16	-0.19	-0.46
Capital Tax	-0.13	-0.21	-1.13	-0.11	-0.21	-1.09	-0.13	-0.22	-1.15	-0.17	-0.27	-1.32	-0.10	-0.19	-1.05

The first three columns of each panel show the first year, second year and long-run multipliers for permanent fiscal shocks normalised to 1% of steady-state output. Multipliers are computed as annual averages in % deviation of output from its initial steady-state. All multipliers are consistent with a fiscal rule specified in terms of lump sum taxes, TAX_t.

Table 6: Long-run fiscal output multipliers - Adjusting τ_t^l

	Baseline			$\phi = 0.8$, $\nu = 1.5$			$\phi = 0.8$, $\nu = 0.5$			$\eta = 1$			$\omega = 0.2$		
	Yr 1	Yr 2	LR	Yr 1	Yr 2	LR	Yr 1	Yr 2	LR	Yr 1	Yr 2	LR	Yr 1	Yr 2	LR
Government consumption	-0.42	-0.05	1.07	-0.37	-0.06	1.12	-0.40	-0.08	0.98	-0.59	-0.29	1.11	-0.42	-0.07	1.10
Government purchases	-0.06	-0.03	0.48	0.05	0.01	0.55	-0.05	-0.06	0.40	-0.05	-0.02	0.54	-0.04	-0.01	0.53
Government wage bill	-0.53	-0.05	1.28	-0.57	-0.09	1.46	-0.54	-0.07	1.20	-0.75	-0.38	1.32	-0.53	-0.0	1.31
Govt. investment	-0.38	-0.83	-3.00	-0.37	-0.85	-3.05	-0.38	-0.84	-3.02	-0.34	-0.8	-2.76	-0.35	-0.82	-2.97
Govt. investment delayed	0.16	0.05	-3.00	0.18	0.06	-3.05	0.16	0.05	-3.02	0.23	0.12	-2.76	0.18	0.05	-2.97
Labour Tax	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Consumption Tax	-0.05	-0.10	0.35	-0.04	-0.07	0.20	-0.04	-0.06	0.23	-0.04	-0.09	0.41	-0.03	-0.09	0.38
Capital Tax	0.01	-0.12	-0.16	0.01	-0.11	-0.16	0.00	-0.12	-0.18	0.04	-0.10	0.00	0.03	-0.09	-0.09

The first three columns of each panel show the first year, second year and long-run multipliers for permanent fiscal shocks normalised to 1% of steady-state output. Multipliers are computed as annual averages in % deviation of output from its initial steady-state. All multipliers are consistent with a fiscal rule specified in terms of lump sum taxes, τ_t^l.

calibration, the higher responsiveness of output following an income tax shock also implies that when government debt is stabilised through a permanent cut in labour income taxes, the positive permanent income effects, together with the increase in labour effort driven by higher net real wages, outweigh the effects that would have otherwise resulted in more negative output multipliers. Thus, the long-run negative effects, government consumption and revenue have on output, are confirmed under this alternative calibration of labour supply elasticity, as long as the fiscal space created by the contractionary fiscal stance are used to reduce labour income taxes. Finally, all multipliers, following both temporary and permanent shocks, are robust to changes in the share of credit-constrained individuals in the model.

6 Conclusion

This paper documents the fiscal block extension to MEDSEA, the Central Bank of Malta's DSGE model. The new fiscal block is fairly detailed, distinguishing between four types of public sector expenditure items; transfers to households, public investment as well as expenditure on final goods and services and public employment which are used by the government to produce a homogeneous public good. Moreover, the model allows for a trade-off to exist between welfare-enhancing public goods and the negative distortionary effects of public expenditure. Furthermore, in light of the reliance of Maltese output on imported content, the model is able to reflect the different degrees of import intensities that characterise both government purchases of goods and services (for consumption purposes) and government investment. Government can raise revenue through three distortionary tax instruments; taxes on labour income, taxes capital income and dividends and taxes on consumption as well as through non-distortionary lump-sum taxes.

Apart from a detailed documentation of the new model, this paper has provided estimates of fiscal multipliers for the Maltese economy. I estimate both short-run and long-run fiscal multipliers for six different distortionary fiscal instruments. Moreover to account for the fact that both short-run and long-run multipliers are likely to be affected by different fiscal instruments used to balance the fiscal budget, I perform two sets of permanent shocks, one with a fiscal rule specified in terms of lump sum taxes and another in which income taxes are allowed to vary.

Despite the different features included in the model, results from MEDSEA confirm a number of stylised facts found in literature. Short-run expenditure multipliers are smaller than one in absolute terms and are larger than short term tax multipliers, especially in the first year of the simulations. Expenditure multipliers in the short-run range between -0.57 in case of a public employment shock to -0.19 in case of a government purchases shock while tax multipliers lie between -0.19 for labour taxes and -0.03 in case of capital taxes. In case the change in fiscal instruments is implemented on a permanent basis, short-run multipliers for both purchases and wage bill components of government consumption are lower in absolute terms than in the case of a transitory implementation. On the revenue side, the output multipliers for labour and capital income taxes, are considerably stronger in the case of permanent shocks. On the other hand, the effects of a change in consumption tax is more pronounced in the case of a temporary shock. In view of stronger positive wealth effects, all short term multipliers are lower in absolute terms (and in the case of capital tax tightening even positive) when the fiscal rule is specified in terms of the labour income tax. Long-run tax multipliers are in line with those of other small open economies such as Estonia, Portugal and Greece as published in Kilponen et al. (2015).

While the economic effects of tax hikes seem to be subdued in the short-run, they are found to have considerable negative effects on potential output in the longer run. Moreover, an increase in capital taxes is found to affect the wealth distribution across different types of households, with Ricardian households (in light of their ownership of capital goods in the economy) experiencing a fall in steady state consumption and investment, and credit-constrained consumers benefiting from lower lump-sum or labour income taxes. Despite the relatively stronger recessionary short-run effects of a government consumption shock, results indicate that a fiscal consolidation exercise based on such a strategy can result in gains in long-run output, especially if the fiscal room created is used to reduce distortionary taxes such as labour income taxes. The positive long-run effects on output of a reduction in government consumption are at odds with estimates derived in the EAGLE model, but confirm conclusions published in Forni et al. (2009). Short-run government consumption multipliers derived from MEDSEA are also considerably smaller in absolute terms than other existing estimates for the Maltese economy following both permanent and transitory government consumption shocks. Divergencies (both in the short and long-run) between the results published here and previous multiplier estimates, can be explained by the fact that unlike models previously applied to the Maltese economy, MEDSEA is able, through its relatively rich fiscal block, to capture the distortionary effects of public employment and the production of public goods as well as to account for the relatively high import content of government purchases. A negative permanent shock to government investment however, is seen to have the most pronounced negative effect on potential output. A series of robustness shocks show that most qualitative conclusions stemming from the baseline model are valid under different calibrations of key parameters. This is especially true under the policy relevant scenario where the fiscal space created by a contractionary fiscal stance is used to reduce labour income taxes.

These results provide a number of policy recommendations. First, in case of a fiscal consolidation scenario, instead of a strategy based solely on expenditure cuts, the government should opt for a combination of tax and expenditure increases in an effort to reduce short term costs. As soon as more fiscal space is created, the strategy should shift to one solely reliant on expenditure cuts through a reduction in government consumption (more precisely a reduction in government employment), while at the same time using any extra fiscal space to reduce either labour or capital income taxes. In light of its substantial long-run effects on potential output, government investment should be increased using any fiscal space created through the reduction in government consumption.

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A Parameter values

In this appendix I report a detailed list of the parameter values used to calibrate the model's steady-state and dynamics.

Table 1: Parameters affecting Steady State Values

Households	
Rate of time preference (β)	0.99
Inverse elasticity of labour supply (η)	2
Habit formation (χ)	0.6
Share of Type-I households (ω)	0.3
Substitution between private and public goods (ν)	1.5
Bias towards private consumption (ϕ)	0.8
Intermediate firms	
Labour share in non-tradables (γ_N)	0.65
Labour share in domestically produced tradables (γ_{XD})	0.60
Productivity of public capital (γ_g)	0.1
Depreciation of public and private capital (δ)	0.04
Final good firms	
Quasi-share of imports in private consumption (α_{C^P})	0.51
Quasi-share of imports in public consumption (α_G)	0.63
Quasi-share of imports in private investment (α_{I^P})	0.66
Quasi-share of imports in public investment (α_{I^G})	0.66
Quasi-share of imports in exports (α_{I^G})	0.49
Elast. of subst. between domestic and imported pri. cons. (η_{C^P})	1.1
Elast. of subst. between domestic and imported pub. purch. (η_G)	1.1
Elast. of subst. between domestic and imported pri. inv. (η_{I^P})	1.1
Elast. of subst. between domestic and imported pub. inv. (η_{I^G})	1.1
Elast. of subst. between exports and foreign output (η_X)	4

Table 2: Mark-ups and Nominal Rigidities

Nominal Rigidities	
Export prices adjustment costs (γ_X)	58.3
Non-tradable prices adjustment costs (γ_{NT})	20.4
Import prices adjustment costs (γ_M)	58.3
Indexation of export prices (ι_X)	0.5
Indexation of non-tradable prices (ι_{NT})	0.5
Indexation of import prices (ι_M)	0.5
Wage Indexation (Hall parameter) (ι_W)	0.95
Mark-ups (Implied elasticities of substitution ε_t)	
Tradable mark-ups $\left(\frac{\varepsilon_t^{XD}}{\varepsilon_t^{XD}-1}\right)$	1.2 (6)
Non-tradable mark-ups $\left(\frac{\varepsilon_t^{NT}}{\varepsilon_t^{NT}-1}\right)$	1.5 (3)
Imports mark-ups $\left(\frac{\varepsilon_t^{M}}{\varepsilon_t^{M}-1}\right)$	1.2 (6)
Wage mark-ups $\left(\frac{\varepsilon_t^{W}}{\varepsilon_t^{W}-1}\right)$	1.3 (4.3)

Table 3: Fiscal Policy

Fiscal Rule	
Sensitivity of instrument to debt target (ϕ_{g1})	±1.5
Sensitivity of instrument to changes in debt (ϕ_{g2})	±15
Sensitivity of instrument to changes in output (ϕ_{g3})	±15
Monetary Policy Rule	
Sensitivity of interest rates to NFA (ρ_ϕ)	0.0002

B Impulse Responses

This appendix presents a number of impulse responses of the main variables of interest to a set of fiscal shocks. All shocks are temporary with an auto-regressive coefficient of 0.9 and have been standardised to 1% of steady state output. Similar to the deterministic simulations carried out in the main text, the fiscal rule is turned off for the first years of the simulation. Due to their short-term nature, these kind of simulations do not reflect the actual implementation of fiscal programmes. However, they are very useful to illustrate the main transmission channels that are explained in the results section of the main text. Unless otherwise stated, all results are in terms of percentage deviations from steady state.

Figure 1: Responses after a government consumption shock

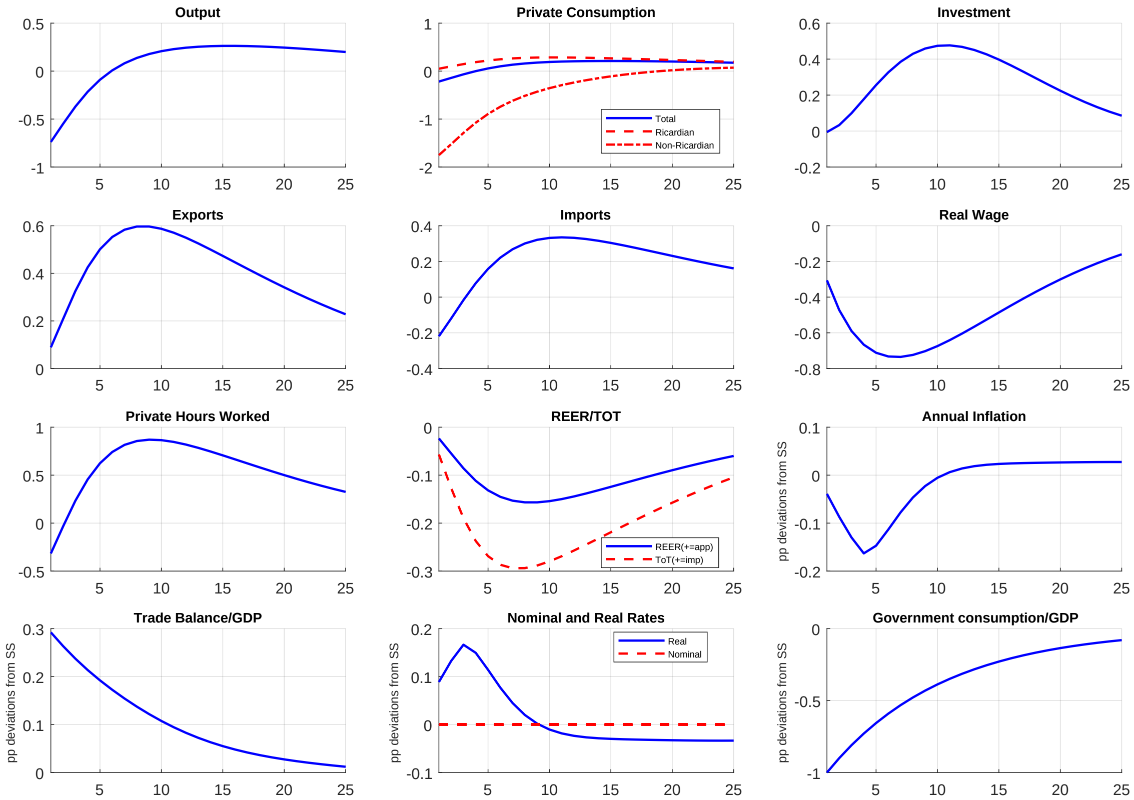

Figure 2: Responses after a government purchases shock

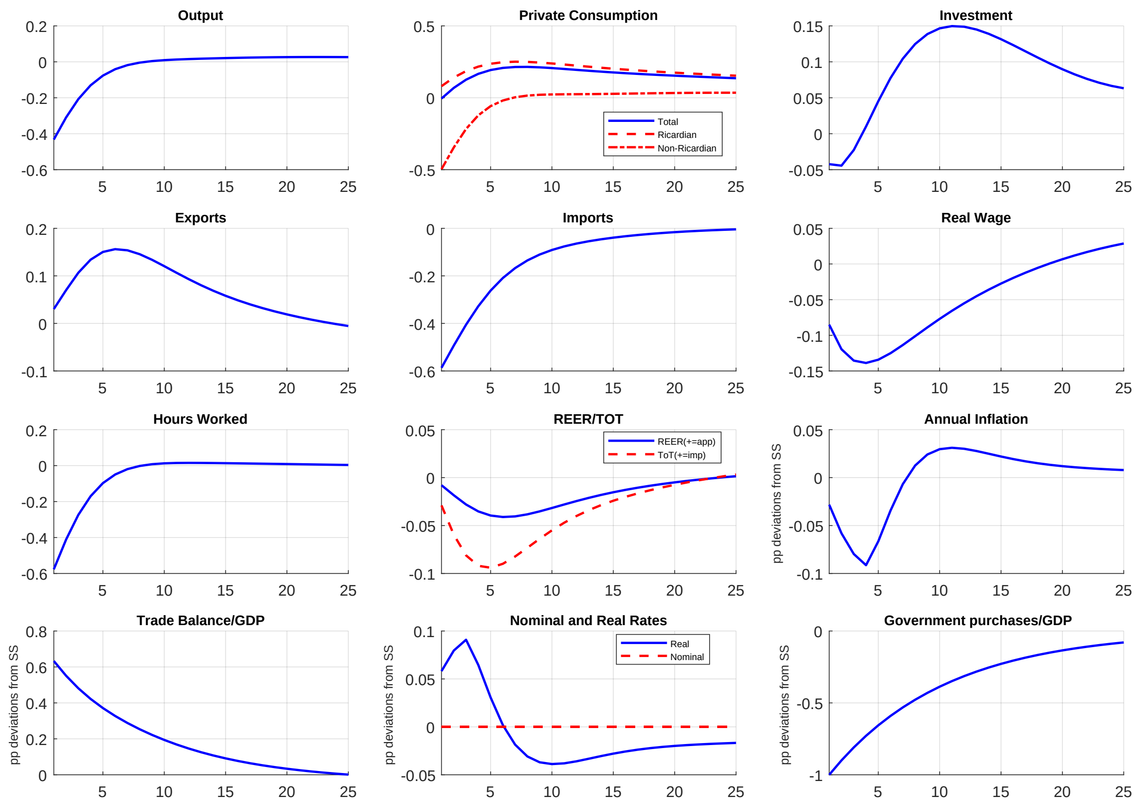

Figure 3: Responses after a government employment shock

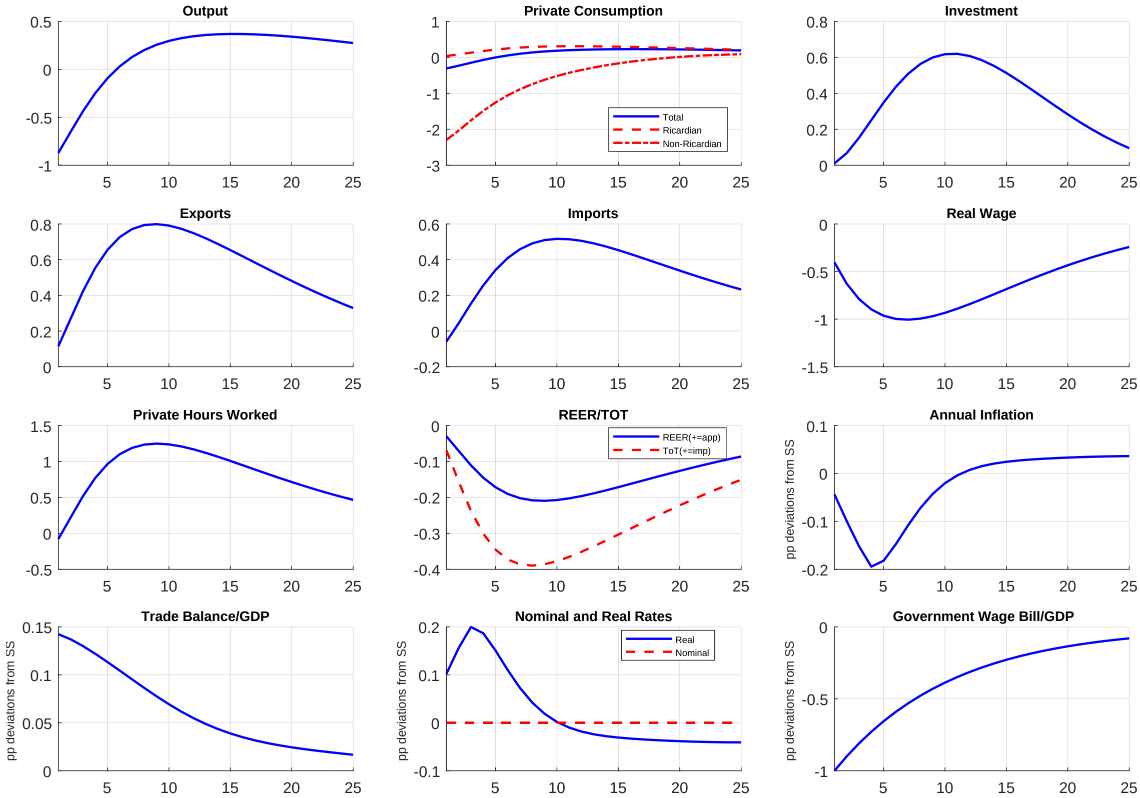

Figure 4: Responses after a government investment shock

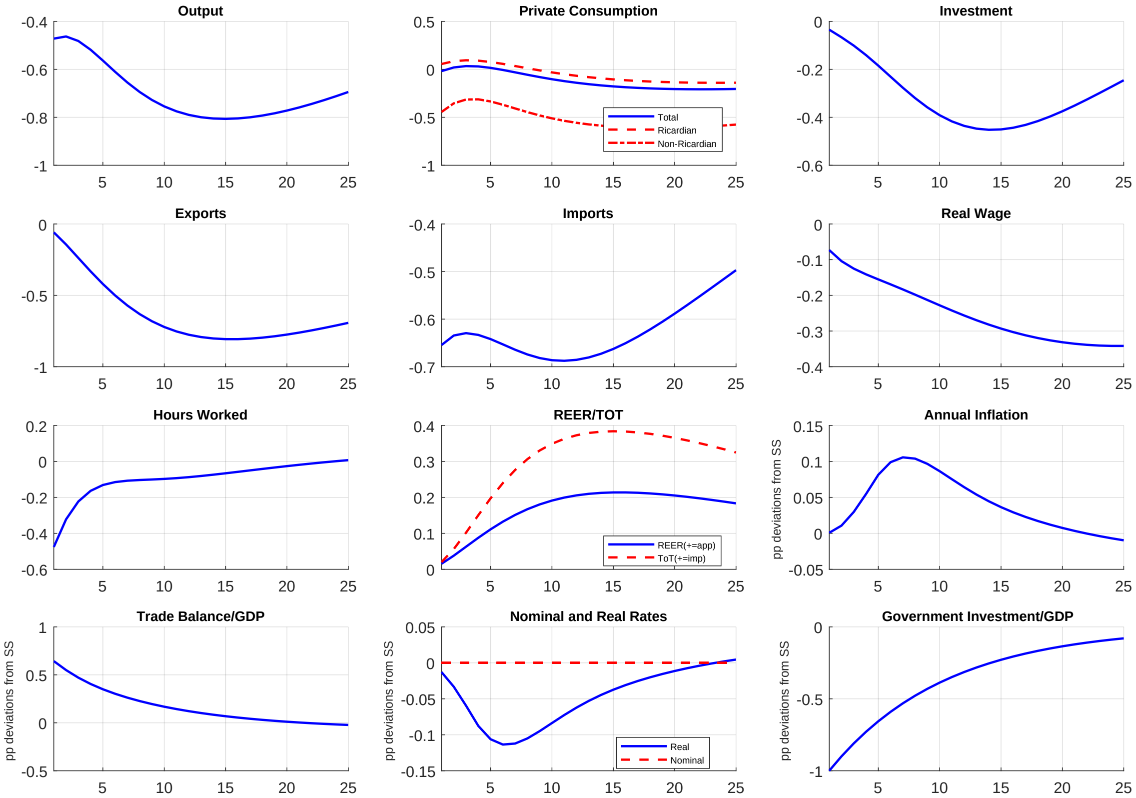

Figure 5: Responses after a labour income tax shock

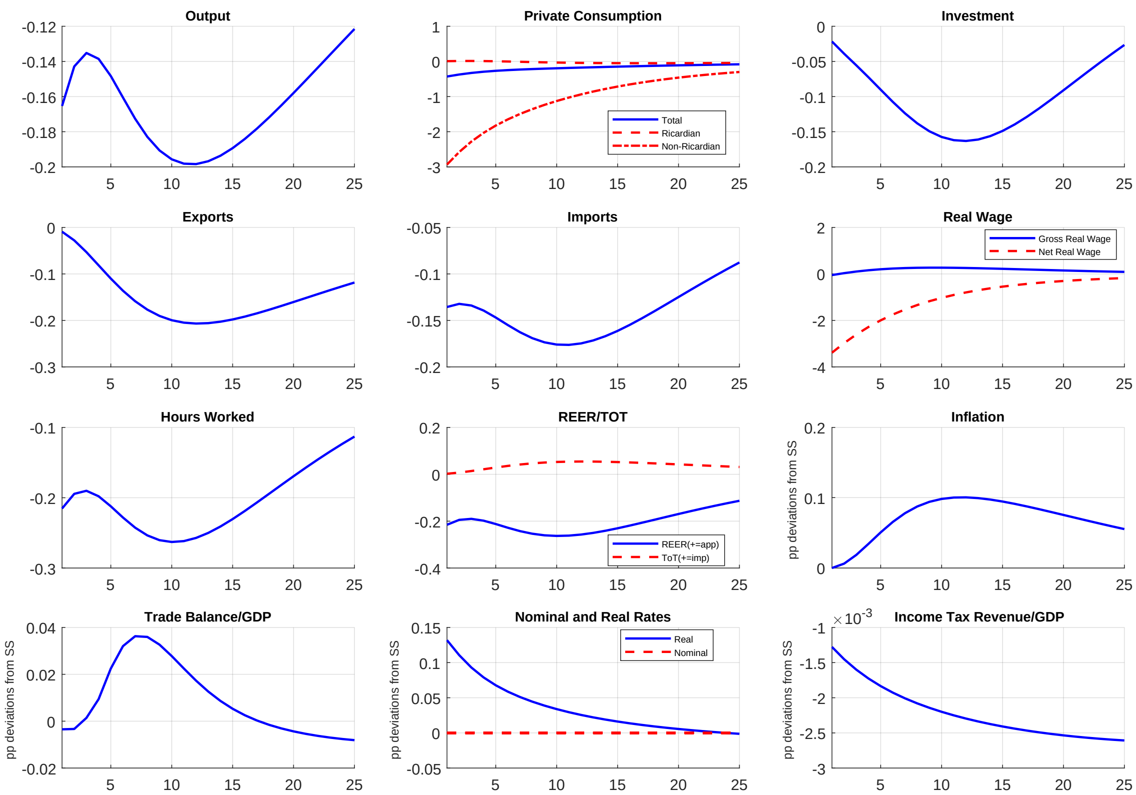

Figure 6: Responses after a consumption tax shock

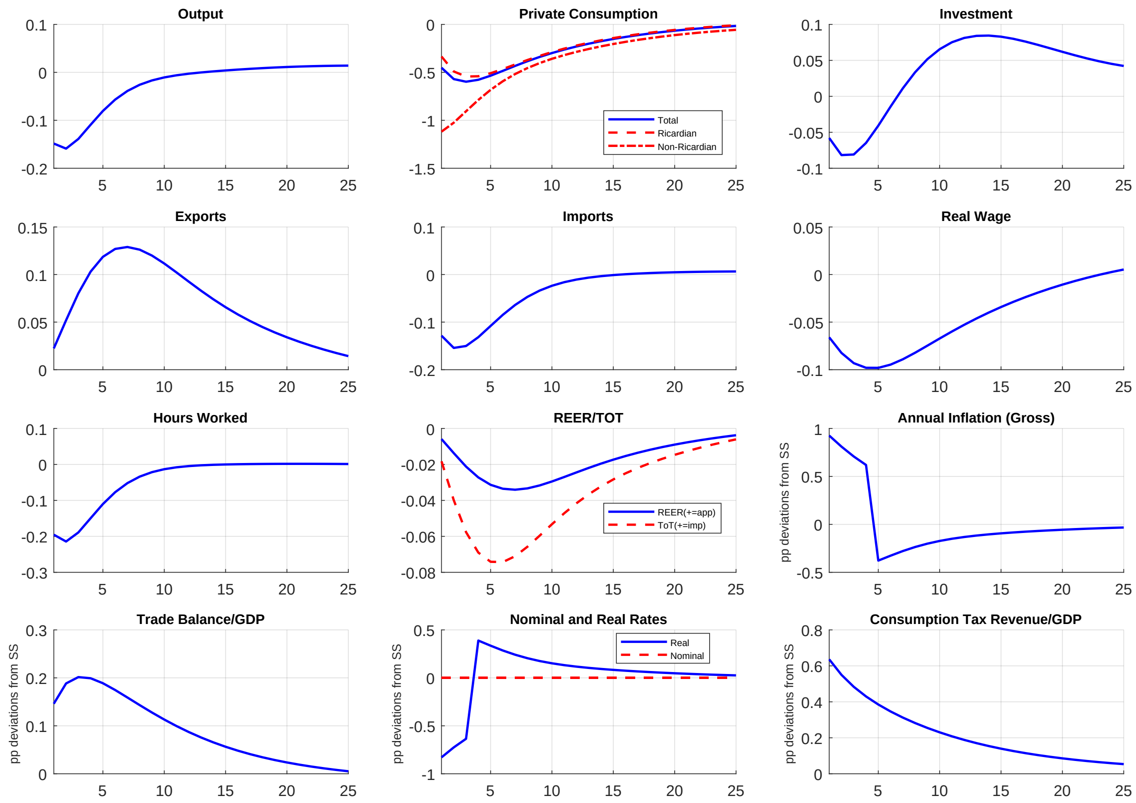

Figure 7: Responses after a capital income tax shock