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A MACROECONOMIC STRUCTURAL MODEL FOR THE PORTUGUESE ECONOMY

Ricardo Mourinho Félix

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Please address correspondence to Banco de Portugal, Economic Research Department, Av. Almirante Reis, no. 71 1150–012 Lisboa, Portugal;
Ricardo Mourinho Félix, tel: # 351-21-3130321, email: rfelix@bportugal.pt

A macroeconomic structural model for the Portuguese economy ⋆

Ricardo Mourinho Félix

Banco de Portugal

Abstract

This paper presents a macroeconomic model with some microfoundations for a small open economy. The main purpose is the simulation of external environment and fiscal policy shocks. The model includes sufficiently disaggregated public sector and household disposable income accounts and it considers a fiscal policy rule that ensures the fulfilment of some budgetary requirements. Thus, the impact in main macroeconomic aggregates of alternative external environment shocks can be evaluated under the assumption that the government automatically adjusts the income tax rate to fulfill these requirements. Furthermore, it is well known that the impact of fiscal policy shocks depends crucially on the economic agents' ability to adjust their behaviour to fiscal policy changes, according to their assessment on future economic developments. Since, this model considers economic agents that form model-consistent expectations, then fiscal policy simulations can be performed properly.

In this study, the model is calibrated for the Portuguese economy and the fiscal rule budgetary requirements (a target fiscal balance of 3% of GDP and a debt-to-GDP ratio target of 60%) correspond to the Stability and Growth Pact excessive deficit thresholds. The simulations presented here can contribute to the current discussion of budgetary consolidation measures in Portugal.

Keywords: structural models, rational expectations, fiscal policy, fiscal rule, Portugal
JEL Classification: C51, E27, E62

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Email address: rfelix@bportugal.pt (Ricardo Mourinho Félix).

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1 Introduction

This paper presents a small open economy macroeconomic model with some microfoundations for external environment and fiscal policy simulations.

Macroeconomic models with microfoundations (also known as structural models) seem more appealing for policy simulation purposes than traditional macroeconometric models. In a structural model, economic agents' decision rules corresponding to reduced-form equations of the traditional macroeconometric models, are derived from optimising behaviour under a set of resource constraints, while the coefficients of the reduced-form equations are expressed as functions of structural model parameters. Whenever a shock on a single structural parameter occurs, a large number of reduced-form coefficients are likely to change, inducing not only a huge instability on these coefficients, but also being subject to the Lucas critique. Structural models are thus better suited for policy simulations than traditional macroeconometric models, not only due to internal consistency, but also due to the improved robustness to the Lucas critique in policy simulation exercises.

The model presented in this study assumes that economic agents are rational, in the sense that they form model-consistent expectations on the future path of the economic variables of interest. Thus, the future impacts of the shocks are computed properly at the time when they plan their expenditure. In addition, the forward-looking behaviour translates into perfect foresight, as the model is fully deterministic. The forward-looking elements contained in the model, specially in price and wage equations, and the fiscal policy rule provide an anchor for price variables, contributing to a faster adjustment of the economy towards steady-state after a shock occurs. The model was designed to mirror the features of a small open economy, integrated in a monetary union subject to budgetary requirements. To cope with this, the usual monetary policy rule is not included and the short-term interest rate and nominal exchange rate are fully exogenous; additionally, a fiscal policy rule was included to ensure that the national government adjusts its fiscal policy to meet the budgetary requirements.

There are five types of economic agents in the model: households, intermediate goods producers, final goods retailers, importers and government.

The supply-side is modelled on the assumption that there is only one good in the economy, which is produced by a representative intermediate goods producer operating under perfect competition. The intermediate goods firm hires labour and capital goods and combines

them using Cobb-Douglas technology; the intermediate good is sold at the marginal cost to final goods retailers, which combine it with imported goods, using also Cobb-Douglas technology and producing differentiated final goods. The final goods retailers operate in a competitive framework, charging a price that is determined as a markup on marginal costs.

Households sell their labour to intermediate goods producers and to government and earn a wage income. Additionally, they pay income taxes and hold all the assets of the economy (including government bonds, firms' capital stock and net foreign assets) and earn the corresponding gross operating surplus. Households choose optimal consumption/saving allocations by maximizing a utility function subject to an intertemporal budget constraint and to a transversality condition. The utility maximization problem considers the stochastic lifetime hypothesis presented in Blanchard (1985).

The government hires labour and pays wage compensations to the civil servants. It also buys some procurement from the private sector to produce a public good that is not traded in the goods market. Moreover, government pays transfers to households and interest to public debt holders. To finance these expenditures, government levies taxes and issues public debt, since seigniorage revenues are not a decision variable for a national government engaged in a monetary union. [1]

The external trade block and the final demand deflators follow Laxton and Pesenti (2003). Export and import volumes are determined by external and global demand, respectively, and by competitiveness in order to account for volume and price effects. The global demand deflators are determined using the cost function of the final goods retailers and depend on domestic and import prices, according to the import content of each global demand component. Finally, import prices are fully exogenous, reflecting the fact that, in a small open economy, importers behave as price takers in international markets.

The model structure is very similar to the EDGE model presented in Kortelainen (2002). Notwithstanding, it includes a more sophisticated public sector accounting scheme, enabling the simulation of more specific fiscal policy shocks, which are not possible to simulate in the EDGE model; additionally, the external trade equations and the final demand deflators are based on theoretical foundations [2] .

[1] Seigniorage revenues are ruled out in the euro area, since money issuing is an ECB monopoly. This does not mean that there are no seigniorage revenues, it means that national governments cannot decide on the amount and they have a minor role in overall revenues.

[2] The EDGE model external trade block and final demand deflators were not derived assuming

The set of simulations presented in this paper comprises external environment and fiscal policy shocks. The first were used to evaluate the model's dynamic features and the response of the main aggregates under a fiscal policy rule. The fiscal shocks were used to assess the impact of alternative fiscal policies in the macroeconomic scenario, considering a fiscal policy rule that uses income tax rate as the default fiscal policy instrument.

This paper has six sections. The next section presents the theoretical foundations behind core behavioural equations and the specifications considered in the model. Section three presents the data set, the simulation methodology, the structural parameter values (including their calibration) and the main baseline assumptions. In section four, the external shocks simulation results are presented so as to provide a closer inspection of the model's main features. Section five presents the results for the fiscal policy shocks and section six concludes.

2 The theoretical foundations behind the main behavioural equations

In modern macroeconomics, models should be built on solid theoretical microfoundations. In particular, this implies that the reduced-form macroeconomic relationships should be explicitly derived from economic agents' optimising behaviour. In fact, if economic agents are believed to behave rationally, in the sense they use all available information in their decision-taking process, then this information set must include not only information on past events, but also the best assessment on future events.

The expectations formation mechanism and the timing at which agents form expectations are crucial, particularly, in the analysis of the impacts of policy shocks, since it determines the way economic agents behave and, in particular, how can they take advantage or avoid the impacts of the shocks. In this model, it is assumed that economic agents form model-consistent expectations, although this translates into perfect foresight, since the model does not include stochastic elements.

The model is inspired by the dynamic general equilibrium model literature that combines the features of neoclassical models with typical short-run rigidities from New Keynesian models. All shocks have significant short-run real impacts, including price shocks, although the model presents long-run neutrality. The adjustment mechanism of the model to demand shocks is provided by the adjustment of prices and wages that influences real

any optimising behaviour of final demand retailers.

wages, unit labour costs and real exchange rates. These adjustments will ultimately determine significant changes in the purchasing power of households [3] and international competitiveness conditions.

Finally, interest rates and exchange rates are assumed to be fully exogenous. In the case of a small open economy in a monetary union, the monetary policy is set by the central bank according to area-wide economic conditions that are not likely to be significantly influenced by idiosyncratic shocks in a small economy. In this context, fiscal policy assumes the role of a macroeconomic stabilisation instrument, since it is the only one available to the national government.

The following subsections describe the way economic agents behave in the model and, in particular, the optimisation problems faced by households and firms. The main behavioural equations of the model correspond to aggregations of representative agents' decision rules.

2.1 The households

The consumption function used in the model is based on Blanchard's stochastic lifetime model [4] and on the approach presented in Sefton and in't Veld (1999). The representative consumer maximizes the expected discounted value of lifetime utility at period t:

$$\max E_t \sum_{j=0}^{\infty} \left(\frac{1}{1+\varphi} \right)^j (1-p)^j \, U\left(c_{t+j}^s\right) \tag{1}$$

where φ is the rate of time preference and $\frac{1}{1+\varphi}$ stands for the usual time discount factor (θ, henceforth); p stands for the constant probability of dying in the next period; and c_{t+j}^s is the consumption of a representative consumer born at period s in period $t+j$.

Assuming a logarithmic utility function that can be derived from a CES utility function under the assumption of constant and unitary elasticity of substitution, the objective function can be expressed as follows:

$$\max E_t \sum_{j=0}^{\infty} \theta^j \, (1-p)^j \ln\left(c_{t+j}^s\right) \tag{2}$$

[3] For instance, the adjustment of prices and wages determines changes in the present value of households' asset wealth and disposable income.
[4] See Blanchard (1985).

The representative consumer is subject to a budget constraint, which in each period t has the following form:

$$c_t^s + w_t^s = \frac{1 + z_{t-1} + \zeta_t}{1 - p} w_{t-1}^s + y_t^s \tag{3}$$

w_t^s stands for the real asset wealth held at period t by a consumer born in period s and y_t^s stands for the real labour income. z_{t-1} and ζ_t stand, respectively, for the expected returns on real asset wealth and windfall gains (the unexpected returns on asset wealth).

From (3) it is straightforward to derive the following intertemporal budget constraint:

$$\sum_{j=0}^{\infty} \frac{(1-p)^j}{\prod_{k=0}^{j-1}(1 + z_{t+k} + \zeta_{t+k+1})} c_{t+j}^s = \sum_{j=0}^{\infty} \frac{(1-p)^j}{\prod_{k=0}^{j-1}(1 + z_{t+k} + \zeta_{t+k+1})} y_{t+j}^s + \frac{1 + z_{t-1} + \zeta_t}{1 - p} w_{t-1}^s \tag{4}$$

A transversality condition has to be imposed in order to prevent consumers from increasing their indebtedness to infinity:

$$\lim_{T \to \infty} E_t \left(\frac{(1-p)^T}{\prod_{k=0}^{T-1}(1 + z_{t+k} + \zeta_{t+k+1})} w_{t+T}^s \right) = 0 \tag{5}$$

Consumer utility maximisation can be solved using standard techniques. The resulting first-order conditions for c_t^s and c_{t+1}^s are:

$$\frac{1}{c_t^s} = \lambda_1 \tag{6}$$

$$\theta \cdot (1-p) \cdot E_t \left(\frac{1}{c_{t+1}^s} \right) = \lambda_1 \cdot E_t \left(\frac{1-p}{1 + z_t + \zeta_{t+1}} \right) \tag{7}$$

by plugging (6) in (7), the following Euler equation can be derived:

$$\theta \cdot E_t \left(\frac{1}{c_{t+1}^s} \right) = \frac{1}{c_t^s} \cdot E_t \left(\frac{1}{1 + z_t + \zeta_{t+1}} \right) \tag{8}$$

Under the assumption of zero risk premia in expected consumption and expected return on real asset wealth, and taking a second order Taylor approximation, the Euler equation collapses to:

$$\theta \cdot E_t (1 + z_t) \cdot c_t^s = E_t \left(c_{t+1}^s \right) \tag{9}$$

By plugging (9) into (4), linearising and assuming that returns on real asset wealth are

uncorrelated, the consumption function at individual level is given by:

$$c_t^s = \big(1 - \theta \cdot (1-p)\big) \left(E_t \sum_{j=0}^{\infty} \frac{(1-p)^j}{\prod_{k=0}^{j-1} (1 + z_{t+k} + \zeta_{t+k+1})} \cdot y_{t+j}^s + \frac{1 + z_{t-1} + \zeta_t}{1-p} \cdot w_{t-1}^s \right) \quad (10)$$

Individual consumption, real disposable income and real asset wealth can be aggregated across cohorts using the following aggregators:

$$PCR_t = \sum_{s=-\infty}^{t} p(1-p)^{t-s} \cdot c_t^s \quad (11)$$

$$WTR_t = \sum_{s=-\infty}^{t} p(1-p)^{t-s} \cdot y_t^s \quad (12)$$

$$ASR_t = \sum_{s=-\infty}^{t} p(1-p)^{t-s} \cdot w_t^s \quad (13)$$

The aggregate budget constraint can be written as:

$$PCR_t + ASR_t = (1 + z_{t-1} + \zeta_t) \cdot ASR_{t-1} + WTR_t \quad (14)$$

and the corresponding consumption function is:

$$PCR_t = \big(1 - \theta \cdot (1-p)\big) \left(E_t \sum_{j=0}^{\infty} \frac{(1-p)^j}{\prod_{k=0}^{j-1} (1 + z_{t+k} + \zeta_{t+k+1})} \cdot WTR_{t+j} + (1 + z_{t-1} + \zeta_t) \cdot ASR_{t-1} \right) \quad (15)$$

After some algebra (15) can be written as follows:

$$PCR_t = \left(\frac{1-p}{1 - (1-p) \cdot (1 - \theta\,(1-p))} \right) \cdot \frac{E_t PCR_{t+1}}{E_t(1 + z_t)} + \left(\frac{p\,(1 - \theta\,(1-p))}{1 - (1-p) \cdot (1 - \theta\,(1-p))} \right) \cdot ((1 + z_{t-1} + \zeta_t) \cdot ASR_{t-1} + WTR_t) \quad (16)$$

Household real disposable income (PYR_t) can be defined as the summation of real asset wealth real return ($z_{t-1} \cdot ASR_{t-1}$) and real labour income WTR_t. Real asset wealth and household real disposable income can be defined respectively as $ASR_t = ASS_t/PCD_t$ and $PYR_t = PYN_t/PCD_t$ respectively, where ASS_t is the nominal asset wealth, PYN_t is households' nominal disposable income and PCD_t is the private consumption deflator.

For the sake of simplicity, windfall gains are assumed to be insignificant and, thus, ζ_t is set to zero. Additionally, expected real returns on real asset wealth are equal to the product

of the real rate of return of risk-free assets by a constant equity premium, $E_t(1+z_t) = (1+r_t)\cdot(1+\chi)$.

Finally, the consumption function that is being used has the following form:

$$\begin{aligned} PCR_t = &\left(\frac{1-p}{1-(1-p)\cdot(1-\theta\,(1-p))}\right)\cdot\frac{E_t PCR_{t+1}}{(1+r_t)\cdot(1+\chi)} \\ &+\left(\frac{p\,(1-\theta\,(1-p))}{1-(1-p)\cdot(1-\theta\,(1-p))}\right)\cdot\left(\frac{ASS_{t-1}}{PCD_t}+\frac{PYN_t}{PCD_t}\right) \end{aligned} \tag{17}$$

Household disposable income can be defined as:

$$\begin{aligned} PYN_t = &YFN_t - RTC_t + DTT_t + (TRX_t + BIN_t + BKA_t) \\ &- RTH_t - SSC_t + GIN_t - \delta\cdot KSR_{t-1}\cdot IND_t \end{aligned} \tag{18}$$

where $YFN_t - RTC_t$ is the after-tax nominal GDP at factor costs; DTT_t and $TRX_t + BIN_t + BKA_t$ are domestic transfers and net income from abroad, respectively; GIN_t are the public interest outlays; RTH_t and SSC_t are taxes on households' income and social security contributions; and $\delta\cdot KSR_{t-1}\cdot IND_t$ is the nominal value of depreciated capital stock.

Asset wealth follows an asset accumulation equation of the following form:

$$\begin{aligned} ASS_t = &\frac{1}{(1+i_t)(1+\chi)}\cdot E_t(ASS_{t+1} - GPD_{t+1} - NFA_{t+1}) \\ &+(YFN_t - WTN_t - \delta\cdot KSR_{t-1}\cdot IND_t - RTC_t) + GPD_t + NFA_t \end{aligned} \tag{19}$$

Equation (19) defines households' nominal asset wealth as the present value of after-tax capital income. GPD_t and NFA_t are the values of public debt and net foreign assets, respectively, representing the present values of income from interest payments and capital income from abroad.

2.2 The firms

2.2.1 The intermediate goods producers

The demand for capital and thus investment are derived from the intermediate goods producer optimisation problem following the approach presented in Hubbard, Kashyap and Whited (1993). Contrary to Kortelainen (2002), in the current formulation it is explicitly considered a corporate income tax; notwithstanding, the no-bond financing assumption is maintained for sake of simplicity.

The representative firm maximises the present value of expected future dividends under the assumption that changing production capacity involves translog adjustment costs. [5] The representative firm's (firm i) problem can be formalized as follows:

$$\max E_t \sum_{j=0}^{\infty} \left[\prod_{h=0}^{t+1} \rho_t \right] \cdot d_{i,t+j} \tag{20}$$

subject to a capital accumulation equation:

$$KSR_{i,t} = INR_{i,t} + (1-\delta) \cdot KSR_{i,t-1} \tag{21}$$

where $\rho_t = \Big((1+r_t)(1+\chi)\Big)^{-1}$ stands for the real discount factor at period t; and δ is the capital stock depreciation rate; $KSR_{i,t}$ and $INR_{i,t}$ stand for firm's i capital stock and investment at period t. $d_{i,t} = D_{i,t}/IND_t$ is firm's i real dividend [6] in period t.

As Γ^c stands for the average corporate income tax, firm's i nominal dividend can be defined as follows:

$$D_{i,t} = (1-\Gamma^c) \cdot (YFN_{i,t} - WTN_{i,t} - \Gamma(KSR_{i,t}, KSR_{i,t-1}, KSR_{i,t-2})) - INR_{i,t} \tag{22}$$

where $\Gamma(KSR_{i,t}, KSR_{i,t-1}, KSR_{i,t-2})$ is the translog adjustment cost function and assumes the following form:

$$\begin{aligned} \Gamma(KSR_{i,t}, KSR_{i,t-1}, KSR_{i,t-2}) &= \frac{a}{2} \frac{(\Delta KSR_{i,t} - b\Delta KSR_{i,t-1})^2}{KSR_{i,t-1}} \\ &\approx \frac{a}{2} \Delta KSR_{i,t} \Delta \log KSR_{i,t} \\ &+ \frac{ab^2}{2} \Delta KSR_{i,t-1} \Delta \log KSR_{i,t-1} \\ &- ab\Delta KSR_{i,t} \Delta \log KSR_{i,t-1} \end{aligned} \tag{23}$$

where a and b stand for adjustment cost parameters and, in particular, $0 < b < 1$. Taking the first-order conditions of the translog adjustment cost function with respect to the capital stock, the optimal level has the following closed form:

$$\begin{aligned} &\rho_t^2 \cdot b\Delta \log KSR_{i,t+2} - (\rho_t^2 \cdot b^2 + \rho_t(1+b))\Delta \log KSR_{i,t+1} \\ &+ (\rho_t \cdot b(1+b) + 1)\Delta \log KSR_{i,t} - b\Delta \log KSR_{i,t-1} \\ &= \frac{1}{a} \left(\frac{YFD_t}{IND_t} \cdot \frac{\partial F(KSR_{i,t}, LTT_t)}{\partial KSR_{i,t}} - \frac{(1+r_t)(1+\chi)(1+\delta)-1}{(1+r_t)(1+\chi)(1-\Gamma^c)} \right) \end{aligned} \tag{24}$$

[5] This type of adjustment cost is thoroughly explained in Tarkka, Willmann and Rasi (1990).
[6] As deflated by the GFCF deflator.

where YFD_t is a value-added deflator, that is, the price of one unit of output expressed in terms of the factor costs (the labour and capital returns); $F(KSR_{i,t}, LTT_{i,t})$ stands for the production function and $LTT_{i,t}$ for the level of employment. As the representative firm's capital stock equation is linear, it can be simply aggregated across firms. Additionally, considering a Cobb-Douglas production function, resulting aggregate capital stock equation is:

$$\begin{aligned} &\rho_t^2 \cdot b\Delta \log KSR_{t+2} - (\rho_t^2 \cdot b^2 + \rho(1+b))\Delta \log KSR_{t+1} \\ &+ (\rho_t \cdot b(1+b) + 1)\Delta \log KSR_t - b\Delta \log KSR_{t-1} \\ &= \frac{1}{a}\left(\alpha \cdot \frac{YFN_t}{IND_t \cdot KSR_t} - \frac{(1+r_t)(1+\chi)(1+\delta)-1}{(1+r_t)(1+\chi)(1-\Gamma^c)}\right) \end{aligned} \tag{25}$$

where α is the capital income share in nominal GDP at factor costs.

The intermediate goods producers' inventory level can be modelled on the assumption that a firm's output level can deviate from optimal at a cost. If economic activity is booming, intermediate goods producer sales tend to rise above optimal output level, and in this case it uses its inventories to face up the unusually high demand. During deceleration periods, optimal output level tends to surpass sales, so firms can produce the optimal output level and use the excess supply to rebuild their inventories.

The optimal output level in each period is obtained from the Cobb-Douglas production function:

$$YET_t = TFT_t \cdot KSR_t^{\alpha} \cdot LTT_t^{1-\alpha} \tag{26}$$

where YET_t is the potential output level as determined by the production function. Additionally, it is assumed that firms target a constant inventories to output ratio (k).

Firms minimize a quadratic loss function combining the losses that they incur from having a higher than desired level of inventories with the losses suffered for not being able to match demand. Thus, the objective function of the firm i is:

$$\frac{1}{2}E_t \sum_{j=0}^{\infty} \rho^j \left[\varpi \left(LSR_{i,t+j} - k \cdot YET_{i,t+j}\right)^2 + \left(YER_{i,t+j} - YET_{i,t+j}\right)^2\right] \tag{27}$$

where $LSR_{i,t}$ and $YER_{i,t}$ stands for inventories and real output respectively.

By taking first-order conditions and solving for $LSR_{i,t}$, the optimal inventories level condition can be derived:

$$LSR_{i,t} = k \cdot YET_{i,t} - \frac{1}{\varpi}\left(YER_{i,t} - YET_{i,t}\right) - \frac{\rho}{\varpi}E_t\left(YER_{i,t+1} - YET_{i,t+1}\right) \tag{28}$$

Since firm inventories level is linear, then aggregation across firms is straightforward:

$$LSR_t = k \cdot YET_t - \frac{1}{\varpi}\left(YER_t - YET_t\right) - \frac{\rho}{\varpi}E_t\left(YER_{t+1} - YET_{t+1}\right) \tag{29}$$

The labour demand level is derived from the Cobb-Douglas production function in order to ensure that it is fully consistent with changes in capital stock and in total factor productivity. Thus, in the long-run, unemployment rate converges to the NAIRU as output converges to its potential level and output gap closes.

Labour demand (LTT_t^*) is derived from the inverted Cobb-Douglas production function of firm i in the following way:

$$LTT_{i,t}^* = \left(\frac{YER_{i,t}}{TFT_{i,t} \cdot KSR_{i,t}^{\alpha}}\right)^{\frac{1}{1-\alpha}} \tag{30}$$

meaning that labour demand is the amount of labour that firm i needs to meet its current demand level, given total factor productivity and capital stock.

In order to capture the smooth profile and the persistence observed in employment data, it is assumed that changing the employment level is costly for firms. In particular, it is assumed that when firms change the amount of labour they hire, they must incur some search and adjustment costs. As in the case of inventories, it is assumed that firm i chooses labour demand in each period by minimizing the following quadratic loss function:

$$\frac{1}{2}E_t\sum_{j=0}^{\infty}\rho^j\left[\left(LTT_{i,t+j} - LTT_{i,t+j-1}\right)^2 + \varrho\left(LTT_{i,t+j} - LTT_{i,t+j}^*\right)^2\right] \tag{31}$$

Taking first order conditions and plugging (30) into $LTT_{i,t}^*$, firm i labour demand in period t is:

$$LTT_{i,t} = \frac{1}{1+\varrho+\rho}LTT_{i,t-1} + \frac{\rho}{1+\varrho+\rho}E_tLTT_{i,t+1} + \frac{\varrho}{1+\varrho+\rho}\left(\frac{YER_{i,t}}{TFT_{i,t} \cdot KSR_{i,t}^{\alpha}}\right)^{\frac{1}{1-\alpha}} \tag{32}$$

Once again, as the representative firm equation is linear in employment, the aggregation is straightforward:

$$LTT_t = \frac{1}{1+\varrho+\rho}LTT_{t-1} + \frac{\rho}{1+\varrho+\rho}E_tLTT_{t+1} + \frac{\varrho}{1+\varrho+\rho}\left(\frac{YER_t}{TFT_t \cdot KSR_t^{\alpha}}\right)^{\frac{1}{1-\alpha}} \tag{33}$$

The prices and wages formation mechanism of the model assumes that the intermediate goods producers price formation scheme follows Rotemberg (1982), exhibiting short-run rigidities, while wages follow the Calvo (1983) adjustment process.

The steady-state price level is derived from firms' profit maximization conditions under perfect competition, thus equating price to marginal cost. However, prices adjust sluggishly and they can deviate from marginal cost in the short-run. The sluggish adjustment also reflects an optimising behaviour, since price changes induce adjustment costs.

Considering perfect competition and assuming that firms' technology can be approximated by a Cobb-Douglas production function, the optimal price level of the representative intermediate goods producer i can be defined as a mark-up on unit labour costs:

$$YFD^*_{i,t} = \frac{WRN_{i,t} \cdot LTT_{i,t}}{(1-\alpha)YER_{i,t}} \tag{34}$$

where $WRN_{i,t}$ is the nominal wage rate.

The short-run price evolution is governed by the Rotemberg (1982) price adjustment scheme, which consists in assuming that representative firm i minimizes the following loss function:

$$\frac{1}{2}E_t \sum_{j=0}^{\infty} \tilde{\rho}^j \left[(YFD_{i,t+j} - YFD_{i,t+j-1})^2 + \mu (YFD_{i,t+j} - YFD^*_{i,t+j})^2 \right] \tag{35}$$

where $\tilde{\rho} = \Big((1 + IST_t) \cdot (1 + \chi) \Big)^{-1}$ stands for the nominal discount factor.

Taking the first-order conditions, solving for $YFD_{i,t}$ and plugging (34) in $YFD^*_{i,t}$ it leads to the following firm level price equation:

$$YFD_{i,t} = \frac{1}{1+\mu+\tilde{\rho}} YFD_{i,t-1} + \frac{\tilde{\rho}}{1+\mu+\tilde{\rho}} E_t YFD_{i,t+1} + \frac{\mu}{1+\mu+\tilde{\rho}} \frac{WRN_{i,t} \cdot LTT_{i,t}}{(1-\alpha)YER_{i,t}} \tag{36}$$

The above firm-level price equation can be aggregated across firms, leading to the following price equation, which is used to model the value-added deflator:

$$YFD_t = \frac{1}{1+\mu+\tilde{\rho}} YFD_{t-1} + \frac{\tilde{\rho}}{1+\mu+\tilde{\rho}} E_t YFD_{t+1} + \frac{\mu}{1+\mu+\tilde{\rho}} \frac{WRN_t \cdot LTT_t}{(1-\alpha)YER_t} \tag{37}$$

The above value-added deflator corresponds to the GDP deflator at factor costs. However, in the determination of final demand deflators it is the market price of a unity of domestic output that is relevant. The GDP deflator at market prices (henceforth called GDP deflator, in opposition to the value-added deflator) can be obtained from the value-added delator simply by adding the net average tax rate on production (τ^y_t): [7]

$$YED_t = YFD_t \cdot (1 + \tau^y_t) \tag{38}$$

[7] In practice, the GDP deflator at market prices is computed by summing net taxes to nominal GDP at factor cost and dividing by real GDP as can be seen in the equations listed at the end of this article.

The nominal wage rate is modelled in the spirit of the Calvo (1983) staggered adjustment framework. It is a very common framework to model sort-run nominal wage rigidity, while ensuring that in the long run the nominal wage rate converges to marginal labour productivity. Rotemberg (1987) and Walsh (1998) present discrete time approaches to the Calvo (1983) staggered adjustment framework.

The key assumption behind the staggered wage adjustment model is that wage contracts at firm level are adjusted infrequently. It is also assumed that the adjustment process can be properly characterized by a Poisson process with a parameter q that corresponds to the probability of a firm being allowed to renegotiate its wage contracts. In each period, the firm i that is allowed to renegotiate the wage rate, resets it to its optimal level by minimising a quadratic loss function that reflects intangible costs incurred in deviating from the optimal wage rate level (wrn^*):

$$\frac{1}{2}\sum_{j=0}^{\infty}(1-q)^j\tilde{\rho}^j E_t\left(wrn_{i,t}-wrn^*_{t+j}\right)^2 \tag{39}$$

Taking first-order conditions and aggregating across firms leads us to the following equation:

$$wrn_t = \left(1-(1-q)\,\tilde{\rho}\right)wrn^*_t + \left((1-q)\,\tilde{\rho}\right)E_t wrn_{t+1} \tag{40}$$

meaning that the nominal wage rate reflects expectations on the evolution of the underlying optimal wages during the period for which wages are settled.

According to the profit maximisation conditions, the optimal wage rate is set to the marginal product of labour. In this model, it is considered that in the short run the optimal wage rate is still influenced by the cyclical position of the economy and, in particular, by labour market slack, as measured by the unemployment-gap. [8] In this context, the optimal wage rate level is such that:

$$wrn^*_t = \frac{YFN\cdot(1-\alpha)}{LTT_t}\cdot\left(1-\eta\left(URX_t-URT_t\right)\right) \tag{41}$$

where wrn^*_t and URT_t stand for the optimal wage rate level and the NAIRU, respectively.

As there are a large number of firms in the economy and as only a fraction q of them adjust their wages towards the optimal wage rate level, the observed nominal wage rate is a weighted average of wages fixed by both types of firms:

$$WRN_t = q\cdot wrn_t + (1-q)WRN_{t-1} \tag{42}$$

By plugging (40) in (42) we arriver at the following nominal wage rate equation that will be directly used in the model:

[8] It must be noted that this optimal wage rate level is not completely derived in an optimising framework. However, this corresponds to assuming that there exists a Phillips curve behaviour, meaning that employees' and employers' bargaining power depends on labour market conditions.

$$WRN_t = \frac{1-q}{1+(1-q)(1-q)\tilde{\rho}} WRN_{t-1} + \frac{(1-q)\tilde{\rho}}{1+(1-q)(1-q)\tilde{\rho}} E_t WRN_{t+1} + \frac{q(1-(1-q)\tilde{\rho})}{1+(1-q)(1-q)\tilde{\rho}} \cdot \left[\frac{YFN \cdot (1-\alpha)}{LTT_t} \cdot (1-\eta\,(URX_t - URT_t)) \right] \tag{43}$$

2.3 The final goods retailers and the importers

Private consumption and investment deflators can be derived on the basis of the existence of a continuum of domestic retailers of final goods and services that operate in perfect competitive markets. Assuming that domestic retailers purchase consumption goods from both domestic and foreign firms and combine them using a Cobb-Douglas production function of the type below to produce a basket of final consumption goods and services:

$$PCR_t = \frac{(PCR_t^H)^{\gamma_1} \cdot (PCR_t^F)^{1-\gamma_1}}{(\gamma_1)^{\gamma_1} \cdot (1-\gamma_1)^{1-\gamma_1}} \tag{44}$$

where PCR_t^H and PCR_t^F stand for domestic and imported real value-added content of the final consumption good, respectively, and γ_1 stands for the share of domestic value-added content per unit of the composite final consumption good.

Assume that both domestic and foreign firms (indexed by $x \in [0,1]$) produce a continuum of differentiated goods indexed by $h \in [0,s]$ and by $f \in [s,1]$, respectively, and where s refers to the country size. In this case, domestic and foreign firms' value-added can be expressed as follows in nominal terms:

$$PCN_t^H = \int_0^s PCN_t(h) \cdot dh = \int_0^1 \int_0^s PCR_t(h,x) \cdot PCD_t^H \cdot dh \cdot dx \tag{45}$$

$$PCN_t^F = \int_s^1 PCN_t(f) \cdot df = \int_0^1 \int_s^1 PCR_t(f,x) \cdot PCD_t^F \cdot df \cdot dx \tag{46}$$

where PCD_t^H and PCD_t^F stand for domestic and imported consumption good prices, respectively.

Under perfect competition, consumption goods retailers act as a price-taker in the differentiated consumption goods market and set their production level by minimizing their cost function $CT_t(h,f,x)$ subject to the Cobb-Douglas technology:

$$\min_{PCR_t(h,x), PCR_t(f,x)} CT_t(h,f,x) = \tag{47}$$
$$\int_0^s PCR_t(h,x) \cdot PCD_t^H \cdot dh + \int_s^1 PCR_t(f,x) \cdot PCD_t^F \cdot df$$
$$+PCD_t \left(PCR_t(x) - \frac{(\int_0^s PCR_t(h,x) \cdot dh)^{\gamma_1} \cdot \left(\int_s^1 PCR_t(f,x) \cdot df \right)^{1-\gamma_1}}{(\gamma_1)^{\gamma_1} \cdot (1-\gamma_1)^{1-\gamma_1}} \right)$$

where PCD_t plays the role of the Lagrange multiplier. It should be noted that, in this case, the Lagrange multiplier is just the marginal cost and under perfect competition, equilibrium price equals marginal cost.

Taking first-order conditions with respect to $PCR_t(h,x)$ and $PCR_t(f,x)$ and using (44) leads us to:

$$\left(\int_0^s PCD_t^H \cdot dh\right)\left(\int_0^s PCR_t(h,x)\cdot dh\right) = \gamma_1 \cdot \left(\int_0^s 1 \cdot dh\right) \cdot PCD_t \cdot PCR_t(x) \tag{48}$$

$$\left(\int_s^1 PCD_t^F \cdot df\right)\left(\int_s^1 PCR_t(f,x)\cdot df\right) = (1-\gamma_1) \cdot \left(\int_s^1 1 \cdot df\right) \cdot PCD_t \cdot PCR_t(x) \tag{49}$$

Taking advantage of the fact that PCD_t^H and PCD_t^F are equal for all firms operating home and abroad and aggregating across firms, we arrive at the usual Cobb-Douglas factor shares:

$$PCD_t^H \cdot PCR_t^H = \gamma_1 \cdot PCD_t \cdot PCR_t \tag{50}$$
$$PCD_t^F \cdot PCR_t^F = (1-\gamma_1) \cdot PCD_t \cdot PCR_t \tag{51}$$

The price at which consumption goods retailers buy home consumption goods is the price set by intermediate goods producers and this is in fact the value-added deflator (YFD_t); and the price at which retailers import foreign consumption good is the imports deflator (MTD_t). Taking this into consideration, the following demand for consumption goods produced home and abroad, respectively, can be derived,

$$PCR_t^H = \gamma_1 \cdot \left(\frac{YFD_t}{PCD_t}\right)^{-1} \cdot PCR_t \tag{52}$$

$$PCR_t^F = (1-\gamma_1) \cdot \left(\frac{MTD}{PCD_t}\right)^{-1} \cdot PCR_t \tag{53}$$

Using (52) and (53) and replacing it in (44) the private consumption deflator can be expressed as follows:

$$PCD_t = \Gamma_1 \cdot YED_t^{\gamma_1} \cdot MTD_t^{1-\gamma_1} \tag{54}$$

Γ_1 is used to capture taxes on consumption such as VAT and mark-up shocks.

The same approach can be applied to the investment goods retailer and to the exporters of home produced goods and the respective deflators are:

$$IND_t = \Gamma_3 \cdot YFD_t^{\gamma_3} \cdot MTD_t^{1-\gamma_3} \tag{55}$$
$$XTD_t = \Gamma_5 \cdot YFD_t^{\gamma_5} \cdot MTD_t^{1-\gamma_5} \tag{56}$$

where IND_t and XTD_t stand for investment and exports deflators, respectively; and γ_3 and γ_5 stand for the the domestic value-added content of one unit of the composite investment and exported goods. γ_3 and γ_5 are used to capture the impact of shocks on taxes and subsidies on production and mark-up shocks on investment and exports deflators.

Finally, in order to allow for the heterogeneous nature of imported goods due to the considerable role of oil imports, it was considered that imports deflator is a weighted average of non-energy imports and energy goods imports deflators:

$$MTD_t = MND_t^{\omega} \cdot MED_t^{1-\omega} \tag{57}$$

where ω is the proportion of energy goods imports in total imports.

The non-energy goods imports deflator (MND_t) is set by assuming purchasing-power parity, as follows:

$$MND_t = \Omega_1 \cdot PMAN_t \cdot EER_t \tag{58}$$

where $PMAN_t$ and EER_t stand for the exports deflator of Portugal's main trading partners and the appropriate effective exchange rate, respectively. The energy goods imports deflator is assumed to follow oil prices in euros:

$$MED_t = \Omega_2 \cdot OIL_t/USD_t \tag{59}$$

where OIL_t and USD_t stand for the oil price in US dollars and the euro-dollar exchange rate respectively. Ω_1 and Ω_2 capture any measurement errors due to changes in weights and in importers' mark-ups.

The volume of Portuguese imports is obtained by adding up the demand of imported goods by domestic retailers of consumption and investment goods derived above. Additionally, consideration must be given to the demand of imported goods by domestic exporters and by the government. [9]

In particular, the demand of imported consumption goods can be obtained by using (53). The result is extremely intuitive, since the volume of imported consumption goods depends of the imported content of private consumption and of real exchange rate and competitiveness conditions of the Portuguese economy.

Applying the same formulation to investment and exports, the following imports equation can be obtained:

[9] It is worth mentioning that usually government consumption has a very low import content.

$$MTR_t = (1-\gamma_1)\cdot\left(\frac{YFD_t}{MTD_t}\right)\cdot PCR_t + (1-\gamma_2)\cdot\left(\frac{YFD_t}{MTD_t}\right)\cdot CGR_t + (1-\gamma_3)\cdot\left(\frac{YFD_t}{MTD_t}\right)\cdot INR_t + (1-\gamma_4)\cdot\left(\frac{YFD_t}{MTD_t}\right)\cdot \Delta LSR_t + (1-\gamma_5)\cdot\left(\frac{YFD_t}{MTD_t}\right)\cdot XTR_t \tag{60}$$

The volume of exports (XTR_t) is ad-hoc and it is assumed to evolve in line with external demand (EXD_t) and real exchange rate as follows:

$$XTR_t = \left(\frac{MTD_t}{YFD_t}\right)^{\varepsilon}\cdot EXD_t \tag{61}$$

where ε is the price elasticity of domestic exports.

2.4 The government

The public sector account is sufficiently disaggregated to enable the simulation of alternative fiscal policy shocks.

On the revenue side, the fiscal revenues are most important ones. The revenue resulting from each type of tax is assumed to evolve in line with the macroeconomic base of the related tax. Thus, indirect taxes are assumed to evolve in line with private consumption; corporate income tax follows gross operating surplus; and finally social security contributions depend on compensation to employees. Throughout the simulation period, it is being assumed that the average tax rates of the previous revenue items are kept unchanged.

Household income tax is the only exception. It is assumed that government uses the income tax revenue to stabilise fiscal balance as a percentage of GDP (SGL_t/YEN_t) and public debt ratio (GPD_t/YEN_t) according to the minimum requirements of the SGP. Thus, the income tax average rate (Γ_t^h) is assumed to vary according to the following fiscal rule:

$$\Gamma_t^h = \Gamma_{t-1}^h + \Phi_1\left(\frac{GPD_{t-1}}{YEN_{t-1}} - \left(\frac{GPD}{YEN}\right)^{tar}\right) - \Phi_2\left(\frac{SGL_{t-1}}{YEN_{t-1}} - \left(\frac{SGL}{YEN}\right)^{tar}\right) \tag{62}$$

where the subscript *tar* is used to indicate the target levels for fiscal balance and public debt as a percentage of GDP. The parameters Φ_1 and Φ_2 assume non-negative values and determine income tax changes in response to fiscal ratios deviations from target levels.

On the expenditure side, the most important item is the compensation to public sector employees. This is assumed to evolve with public sector wages and public sector employment. In order to ensure that relative prices remain unchanged in the steady-state, the public sector wage rate grows at the same rate of the private sector wage rate. Public sector employment is exogenous.

3 The data, the simulation methodology and the baseline

3.1 The data

The model was calibrated using an annual database for the Portuguese economy that runs from 1977 up to 2003. This database combines the Banco de Portugal estimates for the period 2001 to 2003; the national accounts produced by the national statistical office (INE) for the period 1995 to 2000; and the Banco de Portugal historical series for the Portuguese economy for the period 1970-1995. The macroeconomic aggregates levels are anchored to the National Accounts levels and were chain-linked using the Banco de Portugal estimates from 2001 onwards. In order to project macroeconomic aggregates from 1995 backwards, the national accounts were chain-linked using the Banco de Portugal Historical Series and the 1995 National Accounts levels.

3.2 The parameterisation of the model

The parameterisation of the model was based on different pieces of information. The structural parameters were calibrated according to the Portuguese macroeconomic context. The permanent probability of death of an individual was set at 2.5%, meaning that the average lifetime of an individual after entering the working age is around 50 years (corresponding to an average lifetime of 70 years). The parameters referring to the short-run rigidities were set in order to obtain both a reasonable baseline simulation and enough persistence in the simulation of alternative shocks. [10]

The determinants of the long-run growth of the Portuguese economy were kept exogenous, as usual in this type of models. In the long run, population is assumed to remain constant and the capital stock grows in line with GDP, yielding a constant output-capital ratio. In this case, the long-run growth is determined by total factor productivity pace, which was calibrated to ensure that the long-run GDP growth stood at 3% per year, broadly in line with the annual average growth rate of GDP in the period 1993-2003. The steady-state inflation rate was set at 2%, according to the ECB price stability definition. [11] The domestic value-added content of final demand components was calibrated using the Portuguese input-output tables for 1999.

[10] It may be worth mentioning that the parameter used for share of contracts wages adjusted to the optimal wage level in each period seems quite low, since it corresponds to the assumption that wage contracts are reset every three years, which is not the case in Portugal. However, it can be interpreted as if contracts adjust to sub-optimal wage levels every year, taking on average three years to wages reach their optimal level.

[11] The ECB website states clearly that *"The primary objective of the ECB's monetary policy is to maintain price stability. The ECB aims at inflation rates of below, but close to, 2% over the medium term."*

Table 1. Structural parameters of the model

Symbol	Description	Value
g	Steady-state GDP growth rate*	0.03
π	Steady-state inflation rate	0.02
i	Steady-state nominal interest rate	0.04
χ	Equity premium	0.06
δ	Capital stock depreciation rate*	0.065
θ	Households subjective discount factor	0.96
p	Death probability	0.025
α	Capital income share*	0.41
k	Optimal inventory to GDP ratio*	0.47
q	Share of labour contracts adjusted to optimal wage level	0.4
η	Semi-elasticity of nominal wage rate to unemployment gap	0.03
μ	Cost of charging a sub-optimal price level	0.3
b	Cost of accelerating capital stock growth rate	0.992
a	Cost of changing the capital stock	112
ϱ	Cost of hiring a sub-optimal employment level	0.15
ϖ	Cost of holding a sub-optimal inventories level	2
γ_1	Value-added content of private consumption*	0.8
γ_2	Value-added content of government consumption*	0.95
γ_3	Value-added content of GFCF*	0.657
γ_4	Value-added content of inventories*	0.657
γ_5	Value-added content of exports*	0.62
ε	Exports price elasticity	0.6
ω^{NRG}	Weight of energy goods in HICP*	0.0801
ω^{MED}	Weight of oil procurement costs in energy goods consumer price*	0.1
ω	Weight of energy in imports of goods and services*	0.06
θ_1	Fiscal rule adjustment to debt ratio deviations from target	0.005
θ_2	Fiscal rule adjustment to fiscal balance deviations from target	0.2

Finally, fiscal rule targets are set according to the Stability and Growth Pact criteria in the context of the Excessive Debt Procedure: 3% for budget deficit and 60% for debt-to-GDP ratio.

Table 1 presents the list of the structural parameters and their values (* indicates that the value of this parameter was calibrated using data for the Portuguese economy, in particular, the input-output tables).

3.3 The baseline model

To evaluate the long-run features of the model and its stability around the balanced growth path, a baseline simulation up to 2250 was conducted. [12] The results reveal that

[12] The model simulations were performed using TROLL, which includes the Laffarge-Boucekkine-Juillard (LBJ) algorithm to solve this type of model. A description of this algorithm, which is able to solve linear and nonlinear forward-looking models in an efficient and robust way, can be found in Juillard, Laxton, McAdam and Pioro (1998). In comparison with the traditional

the projected path is trend stationary and that the main variables converge to their steady-state growth rates and levels in a reasonable time span (see Table 2 and Figure 1 [13]). In fact, most variables converge to their steady-state in less than ten years, in particular, output gap closes in five years and the unemployment rate converges to NAIRU in not more than ten years.

To run the baseline simulation, it was necessary to build a scenario up to 2250 for the exogenous variables using the steady-state growth rates. Exogenous real variables (e.g. external demand, public consumption and public investment exogenous components) are assumed to grow at the pace of potential output. A steady-state growth rate of 3 per cent has therefore been considered. For the exogenous price variables (e.g. manufactured goods prices and oil prices), a 2 per cent steady-state inflation rate was assumed, in line with the above mentioned ECB price stability definition. Finally, a constant value has therefore been considered for interest rates and exchange rates and the NAIRU is at 5.5%. [14]

It should be noted that the baseline simulation cannot be considered as a projection, since exogenous variables are set to their long-run growth rates from 2004 onwards, which is not the most likely scenario in the short-run.

Fair-Taylor algorithm, LBJ is considerably faster and less prone to failure.

[13] The grey dashed line in the graphics represents the steady-state growth rates of the variables

[14] In Luz and Pinheiro (1993), Marques and Botas (1997) and Gaspar and Luz (1997) some evidence is presented showing that the Portuguese NAIRU has been stable at around 6%. In 1998, the Employment Survey underwent significant methodological changes; the statistical break induced by these changes led to an the unemployment rate time series that is lower than the previous one by 0.5 to 1 percentage point. According to recent NAIRU estimates presented in Dias, Esteves and Félix (2004), the figure now stands at around 5.5%.

Table 2. The baseline

	2003	2004	2005	2006	2010	2015	2020	2050	2100
Prices and costs									
HICP	3.3	2.6	2.2	2.3	2.6	2.4	2.1	2.0	2.0
Energy	4.9	2.1	2.2	2.4	2.7	2.4	2.1	1.9	2.0
Non-Energy	3.1	2.7	2.2	2.3	2.6	2.4	2.1	2.0	2.0
GDP deflator	2.4	2.2	2.2	2.4	2.8	2.5	2.1	1.9	2.0
Private consumption deflator	3.3	2.6	2.2	2.3	2.6	2.4	2.1	2.0	2.0
GFCF deflator	0.9	1.6	2.1	2.2	2.5	2.3	2.1	2.0	2.0
ULC, whole economy	3.4	1.3	1.7	2.4	2.8	2.5	2.2	1.9	2.0
Compensation per employee	2.9	3.4	4.3	4.7	5.3	5.3	5.2	5.0	5.1
Productivity, whole economy	-0.5	2.1	2.5	2.3	2.4	2.7	2.9	3.0	3.0
Real compensation per employee	-0.5	0.8	2.1	2.4	2.6	2.8	3.0	3.0	3.0
Imports deflator	-1.4	1.6	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Exports deflator	-1.8	3.5	2.1	2.2	2.5	2.3	2.1	2.0	2.0
Economic Activity									
(constant prices)									
Real GDP	-1.2	2.2	2.7	2.5	2.5	2.7	2.9	3.0	3.0
Private consumption	-0.5	6.2	2.8	2.8	2.8	2.8	2.9	2.9	3.0
Government consumption	0.0	2.2	2.4	2.6	2.8	2.9	3.0	3.0	3.0
GFCF	-9.7	-6.4	0.7	1.2	2.9	3.7	3.7	2.9	3.0
Exports (goods and services)	4.1	0.8	2.9	2.9	2.7	2.8	2.9	3.0	3.0
Imports (goods and services)	-0.7	1.9	3.0	2.9	3.5	3.5	3.3	2.9	3.0
Domestic demand	-2.9	2.8	2.5	2.6	3.0	3.3	3.4	3.2	3.2
Inventories	0.0	-0.1	0.5	0.1	0.0	0.1	0.1	0.0	0.0
Net exports	1.8	-0.6	-0.3	-0.3	-0.6	-0.6	-0.5	-0.3	-0.3
Real disposable household income	-0.5	1.3	2.9	2.6	2.8	2.9	3.0	2.9	3.0
Compensation to employees	2.2	3.5	4.4	4.9	5.4	5.3	5.2	5.0	5.1
Households saving ratio	11.5	7.3	7.3	7.1	6.7	6.8	7.2	7.0	6.2
Trade balance (% GDP)	-5.8	-5.5	-5.5	-5.4	-5.7	-6.4	-7.0	-6.3	-5.9
Curr. + cap. account (% GDP)	-3.0	-2.6	-2.6	-2.6	-3.0	-4.0	-4.8	-6.1	-6.5
Fiscal Developments									
(as a % of GDP)									
Total receipts	43.5	44.0	43.9	44.0	44.1	43.8	43.5	44.2	44.7
Total expenditures	47.7	47.6	47.3	47.2	46.9	46.5	46.3	47.4	47.7
Balance	-4.2	-3.6	-3.4	-3.2	-2.9	-2.7	-2.7	-3.2	-2.9
Primary expenditures	44.8	44.8	44.7	44.7	44.5	44.1	43.9	44.8	45.2
Govt. primary budget balance	-1.3	-0.8	-0.8	-0.7	-0.4	-0.3	-0.4	-0.6	-0.5
Gross Debt	59.9	61.0	61.5	61.8	61.6	59.9	58.8	66.0	62.2
Supply and labour market conditions									
Capital stock	1.5	1.4	1.3	1.3	1.6	2.3	2.8	3.0	3.0
Total employment	-0.7	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Unemployment rate (% of labour force)	6.4	6.3	6.2	6.1	5.8	5.6	5.5	5.6	5.6
Output gap (% GDP)	-0.6	-0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0

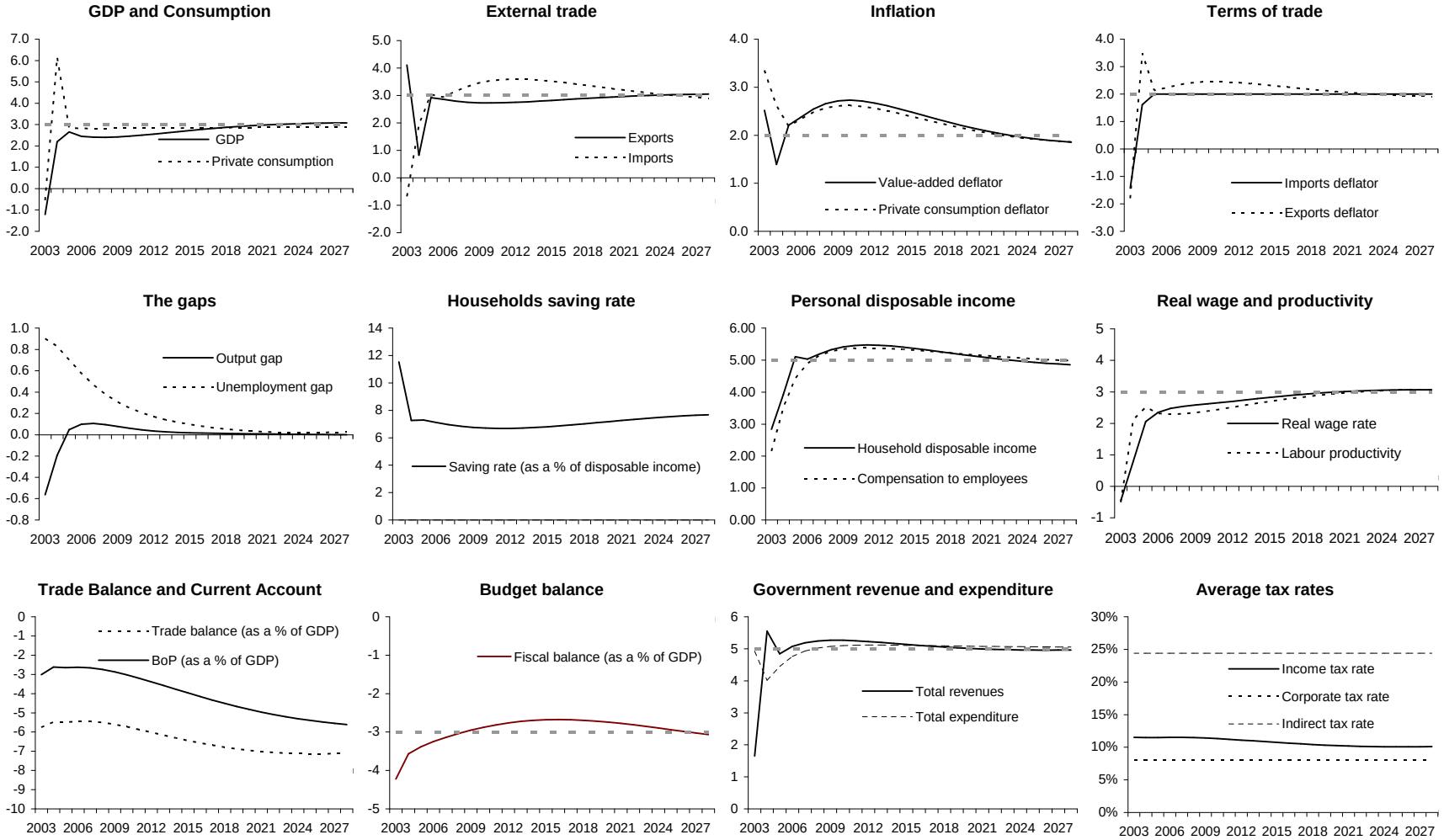

Figure 1. The baseline

4 Simulating shocks on the external environment

The simulation of a set of shocks on the external environment of the Portuguese economy was conducted to evaluate the dynamic features of the model. These simulations are performed under the assumption that the remaining variables characterising the external environment remain at their baseline levels. Thus, the impact of some shocks on the Portuguese economy is likely to be somewhat underestimated/overestimatated since spillover effects, stemming from the impacts of the shock on the euro area, are not being taken into account.

The model that is being used includes forward-looking variables. It should be mentioned that, in this case, the impacts of the shocks depend crucially on the time period at which economic agents notice the shock and include it in their information sets. Thus, it should be clear that the shocks simulated are not anticipated by economic agents, meaning that shocks are only known at the time when they occur. [15]

Additionally, it should be reinforced that the government is committed to the budgetary criteria and adjusts the income tax rate smoothly in order to met the deficit and debt-to-GDP ratio targets (3% and 60%, respectively) in the medium term.

The following external environment shocks were simulated:

(1) an external demand shock;
(2) a risk premium shock;
(3) an effective exchange rate appreciation;
(4) a terms of trade shock;
(5) a technology shock.

The next subsections discuss the implementation and the results of these simulations.

4.1 External demand shock

The external demand shock consists in simulating a permanent 1% increase in the weighted average of Portugal's main trading partners' import volumes, corresponding to a 1% increase in the demand for Portuguese exports. The detailed results of this simulation are presented in Table 3 and in Figure 2.

The short-run impact of this shock in economic activity is significantly positive, mainly reflecting the increase in exports, GFCF and private consumption. However, in the long run the impact on economic activity is somewhat mitigated by the price and wage adjust-

[15] Economic agents are not able to adjust their behaviour previously to the shock in order to avoid or take advantage of the impacts.

Table 3. Permanent 1% increase in external demand

	t	*t+1*	*t+2*	*t+3*	*t+4*	*t+5*	*t+10*	*t+15*	*t+20*
Prices and costs									
HICP	0.15	0.28	0.38	0.44	0.48	0.49	0.42	0.37	0.35
Energy	0.16	0.31	0.43	0.50	0.54	0.55	0.47	0.42	0.40
Non-Energy	0.14	0.28	0.38	0.44	0.47	0.48	0.42	0.37	0.35
GDP deflator	0.18	0.35	0.48	0.56	0.60	0.61	0.53	0.47	0.44
Private consumption deflator	0.15	0.28	0.38	0.44	0.48	0.49	0.42	0.37	0.35
GFCF deflator	0.12	0.23	0.30	0.35	0.38	0.38	0.33	0.29	0.28
ULC, whole economy	0.15	0.41	0.56	0.64	0.65	0.64	0.51	0.45	0.42
Compensation per employee	0.30	0.48	0.58	0.63	0.65	0.64	0.58	0.55	0.53
Productivity, whole economy	0.15	0.07	0.02	0.00	-0.01	0.00	0.07	0.10	0.11
Real comp. per employee	0.15	0.20	0.20	0.19	0.17	0.16	0.16	0.18	0.18
Imports deflator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports deflator	0.11	0.21	0.29	0.33	0.36	0.36	0.31	0.28	0.26
Economic Activity									
(constant prices)									
Real GDP	0.21	0.16	0.10	0.06	0.04	0.03	0.07	0.10	0.11
Private consumption	0.19	0.20	0.20	0.20	0.20	0.20	0.21	0.22	0.23
Government consumption	0.10	0.13	0.13	0.12	0.11	0.10	0.10	0.11	0.12
GFCF	0.07	0.13	0.19	0.24	0.28	0.32	0.38	0.35	0.30
Exports (goods and services)	0.93	0.87	0.83	0.80	0.79	0.78	0.81	0.83	0.84
Imports (goods and services)	0.63	0.81	0.92	0.99	1.03	1.04	0.99	0.94	0.91
Domestic demand	0.16	0.19	0.20	0.21	0.22	0.23	0.28	0.31	0.33
Changes in inventories	-0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Net exports	0.07	-0.04	-0.11	-0.16	-0.19	-0.20	-0.21	-0.21	-0.21
Disposable household income	0.37	0.46	0.52	0.57	0.61	0.64	0.66	0.66	0.66
Compensation to employees	0.36	0.57	0.67	0.70	0.69	0.67	0.58	0.55	0.53
Household saving ratio	0.03	-0.02	-0.05	-0.06	-0.06	-0.05	0.03	0.06	0.08
Trade balance (% GDP)	0.12	0.07	0.04	0.02	0.01	0.01	0.02	0.03	0.03
Curr. + cap. account (% GDP)	0.11	0.07	0.04	0.03	0.02	0.01	0.02	0.03	0.04
Fiscal Developments									
(as a % of GDP)									
Total receipts	-0.04	-0.05	-0.07	-0.09	-0.11	-0.13	-0.17	-0.19	-0.19
Total expenditures	-0.15	-0.19	-0.21	-0.22	-0.22	-0.23	-0.21	-0.20	-0.18
Balance	0.12	0.14	0.14	0.13	0.12	0.10	0.04	0.01	-0.01
Primary expenditure	-0.14	-0.16	-0.18	-0.19	-0.19	-0.19	-0.17	-0.16	-0.16
Govt. primary budget balance	0.10	0.11	0.11	0.10	0.08	0.06	0.00	-0.03	-0.04
Gross Debt	-0.34	-0.53	-0.68	-0.80	-0.89	-0.95	-0.99	-0.83	-0.61
Supply and labour market conditions									
Capital stock	0.01	0.01	0.03	0.04	0.06	0.08	0.18	0.25	0.28
Total employment	0.06	0.09	0.08	0.06	0.05	0.03	0.00	0.00	0.00
Unemployment rate (% of labour force)	-0.06	-0.08	-0.08	-0.06	-0.04	-0.03	0.00	0.00	0.00
Output gap (% GDP)	0.17	0.10	0.04	0.00	-0.01	-0.02	0.00	0.00	0.00

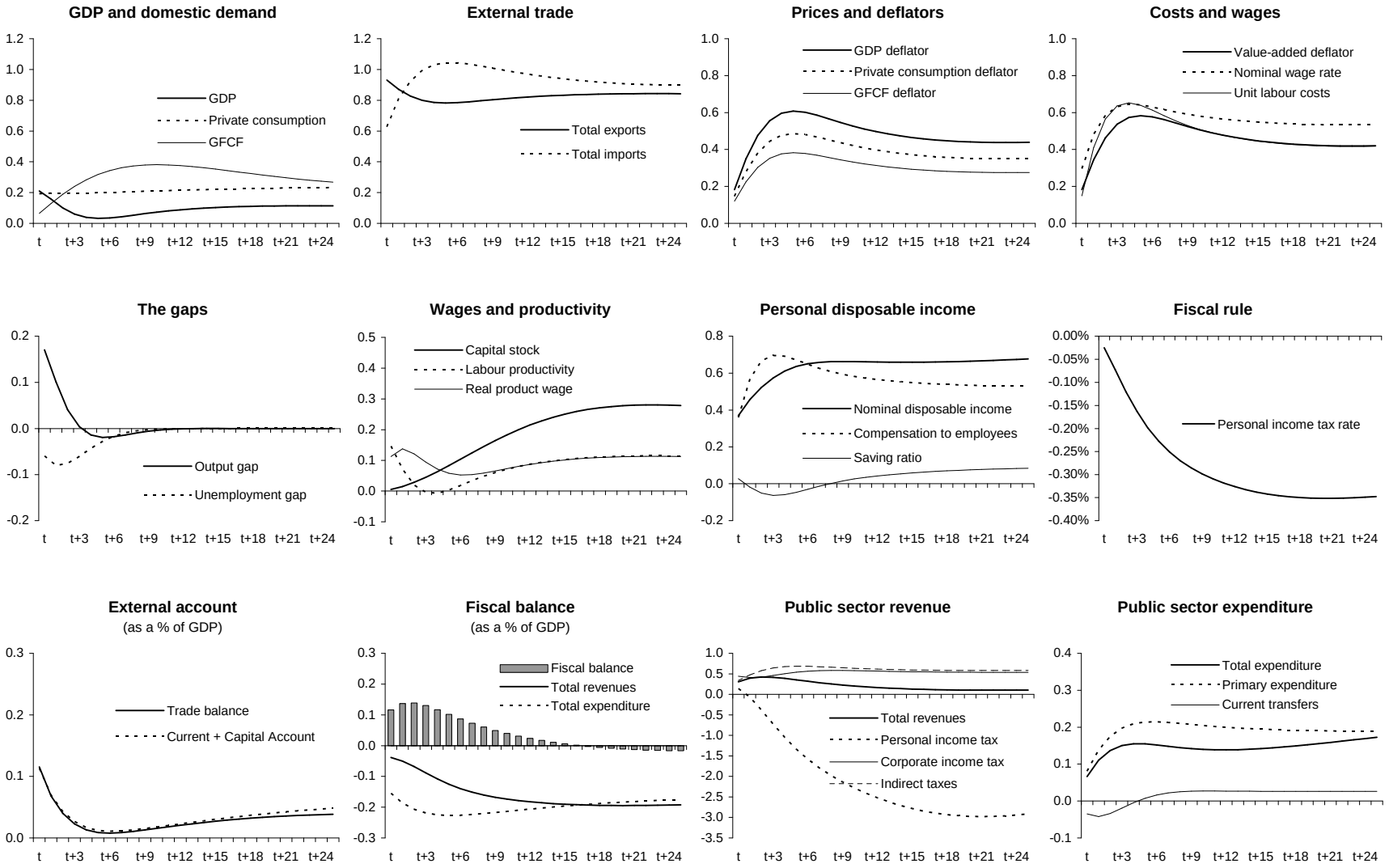

Figure 2. Permanent 1% increase in external demand

ments. In fact, the short-run impacts on nominal wages and in the value-added deflator are near a half of their long-run impacts. Thus, the adjustment towards a new steady-state encompasses a deterioration in the competitiveness conditions of the Portuguese economy, moderating the impact of the shock on exports and slightly boosting the impact on imports.

Nevertheless, the increase in external demand has a small but still positive long-run impact on GDP level, meaning that the shock has a positive impact on potential output. This permanent impact reflects the increase in capital stock due to the permanent change in relative prices of domestic value-added and investment goods. In fact, the value-added deflator (as measured by the GDP deflator at factor costs) increases more than the investment deflator, since the latter is partly tied to import prices and a significant part of the investment goods are produced abroad. Thus, firms' profit maximization conditions point towards a permanent increase in the capital stock level to take advantage of this relative price change.

Despite the long-run impact on output being small, the impact of this shock on expenditure composition is far from negligible. The role of external trade increases considerably, not only due to a permanent increase in exports, but also to the permanent increase in imports, mainly driven by the impact of the shock on the overall demand components with highest import content (consumption, investment and exports). Private consumption jumps immediately to the new steady-state level as households foresee a permanent increase in real disposable income, with real wages increasing and the income tax rate declining.

The public sector benefits considerably from this shock, since most revenue items evolve in line with economic activity and prices, whereas expenditure benefits from the fall in the unemployment rate in the short run and from the fact that part of the public expenditure is exogenous (e.g. government procurement and public investment). The fiscal rule determines that the above mentioned slack is used by the government to lower the average income tax rate. In the long run, both budget deficit and debt ratio revert to their baseline levels. However, the weight of the public sector in the economy (as measured by the public expenditure to GDP ratio) declines permanently.

The trade balance[16] improves in the short run reflecting the increase in export volume and the the slight improvement in terms of trade. However, in the long run, it returns to its baseline level as imports increase, reflecting the above mentioned behaviour of global demand components and the deterioration in competitiveness conditions.

[16] The trade balance variables are always referred to as a percentage of nominal GDP level.

4.2 Risk premium shock

The risk premium shock consists in simulating a 50 basis points permanent increase in the short-term interest rate.[17] Since euro area monetary policy and, in particular, money market interest rates evolve in line with the ECB main refinancing operations interest rate, then short term interest rates are assumed to be exogenously fixed.

The permanent increase in the risk premium of the Portuguese economy translates into an increase in the interest rates that are relevant for domestic economic agents.[18] The detailed results of the simulation are presented in Table 4 and in Figure 3.

Interest rates play a key role in pinpointing the private consumption and the GFCF steady-state levels, since they determine the opportunity cost of consuming and investing in risky assets instead of buying risk-free assets. As this cost increases, households choose to reduce their consumption levels and firms adjust their capital stock downwards permanently, leading to a decline in domestic demand and in GDP, despite the corresponding fall in imports.

The depressive impact on economic activity deriving from an increase in the risk premium is stronger in the short run, leading to an excess supply that triggers price and wage adjustment. In the long run, the fall in prices and wages provoked by the short-term excess supply promotes a decline in domestic output prices. The improvement in competitiveness conditions, stemming from the decline in domestic prices, translates into an increase in exports and an additional decline in imports, reflecting the substitution of imports by domestic production. In turn, this price adjustment boosts the short-run impact, benefiting the trade balance significantly and determining a permanent decline in the net borrowing requirements of the economy (as measured by the current plus capital account deficit).

Finally, there is a sizeable permanent increase in public sector expenditure, both in primary expenditure and in public debt interest outlays (as a % of GDP). The increase in risk premium leads to a similar increase in the public debt interest rate.[19] This increase in interest payments to households should be almost neutral in household disposable income, since the short-run increase in other personal income will be offset by the increase in income tax revenues. The level of primary expenditure decreases mainly due to the decline in compensations to civil servants, however the increase in unemployment leads to higher transfers to households, partially offsetting the previous impact. All in all, the primary expenditure level falls in absolute terms, but its ratio to nominal GDP increases.

[17] The short-term interest rate considered in the model is the 3-month EURIBOR. The remaining nominal interest rates considered in the model evolve in line with the short-term interest rate.
[18] This shock is simulated on the assumption that all economic agents are subject to the same increase in the risk premium, meaning that households, government and firms are treated similarly.
[19] The 50 basis points increase in public debt interest rates corresponds to a 25% increase in the public debt interest rate.

Table 4. Permanent 50 b.p. increase in risk premium

	t	*t+1*	*t+2*	*t+3*	*t+4*	*t+5*	*t+10*	*t+15*	*t+20*
Prices and costs									
HICP	-0.83	-1.56	-2.11	-2.45	-2.62	-2.67	-2.37	-2.14	-2.03
Energy	-0.93	-1.76	-2.37	-2.75	-2.94	-2.99	-2.66	-2.40	-2.28
Non-Energy	-0.82	-1.55	-2.09	-2.42	-2.59	-2.64	-2.34	-2.12	-2.01
GDP deflator	-1.03	-1.95	-2.63	-3.05	-3.26	-3.32	-2.95	-2.67	-2.53
Private consumption deflator	-0.83	-1.56	-2.11	-2.45	-2.62	-2.67	-2.37	-2.14	-2.03
GFCF deflator	-0.44	-1.02	-1.44	-1.70	-1.83	-1.87	-1.64	-1.46	-1.38
ULC, whole economy	-0.62	-1.97	-2.78	-3.14	-3.22	-3.15	-2.53	-2.25	-2.12
Compensation per employee	-1.44	-2.35	-2.84	-3.05	-3.09	-3.05	-2.69	-2.50	-2.39
Productivity, whole economy	-0.83	-0.39	-0.06	0.10	0.14	0.11	-0.16	-0.26	-0.28
Real comp. per employee	-0.62	-0.80	-0.75	-0.62	-0.49	-0.39	-0.33	-0.37	-0.36
Imports deflator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports deflator	-0.42	-0.96	-1.36	-1.61	-1.73	-1.77	-1.55	-1.38	-1.30
Economic Activity									
(constant prices)									
Real GDP	-1.19	-0.88	-0.53	-0.29	-0.14	-0.09	-0.21	-0.30	-0.31
Private consumption	-3.05	-3.09	-3.04	-3.01	-2.98	-2.96	-2.88	-2.84	-2.82
Government consumption	-0.40	-0.52	-0.48	-0.40	-0.31	-0.25	-0.21	-0.24	-0.23
GFCF	-0.12	-0.27	-0.42	-0.57	-0.70	-0.82	-1.05	-0.93	-0.70
Exports (goods and services)	0.25	0.58	0.83	0.98	1.05	1.08	0.94	0.84	0.79
Imports (goods and services)	-1.58	-2.52	-3.08	-3.40	-3.56	-3.61	-3.34	-3.08	-2.91
Domestic demand	-2.16	-2.27	-2.30	-2.34	-2.38	-2.44	-2.73	-2.96	-3.16
Changes in inventories	0.11	-0.06	-0.07	-0.04	-0.02	0.00	-0.01	-0.01	0.00
Net exports	0.83	1.44	1.84	2.10	2.27	2.37	2.53	2.67	2.85
Disposable household income	-1.85	-2.21	-2.48	-2.71	-2.88	-3.01	-3.21	-3.26	-3.29
Compensation to employees	-1.80	-2.84	-3.30	-3.42	-3.36	-3.24	-2.73	-2.54	-2.42
Household saving ratio	1.89	2.27	2.49	2.56	2.53	2.44	1.90	1.59	1.43
Trade balance (% GDP)	0.41	0.66	0.80	0.88	0.92	0.94	0.87	0.80	0.76
Curr. + cap. account (% GDP)	0.23	0.49	0.65	0.76	0.83	0.87	0.95	0.97	0.98
Fiscal Developments									
(as a % of GDP)									
Total receipts	0.01	0.14	0.29	0.46	0.62	0.77	1.25	1.46	1.54
Total expenditures	1.11	1.41	1.58	1.68	1.74	1.77	1.71	1.59	1.47
Balance	-1.09	-1.27	-1.29	-1.22	-1.12	-1.00	-0.46	-0.13	0.07
Primary expenditure	0.84	1.00	1.07	1.11	1.12	1.11	1.01	0.94	0.91
Govt. primary budget balance	-0.83	-0.86	-0.78	-0.65	-0.49	-0.34	0.23	0.52	0.63
Gross Debt	2.39	3.93	5.25	6.33	7.19	7.83	8.82	7.82	6.01
Supply and labour market conditions									
Capital stock	-0.01	-0.03	-0.06	-0.10	-0.15	-0.20	-0.48	-0.67	-0.71
Total employment	-0.36	-0.49	-0.47	-0.38	-0.28	-0.19	-0.04	-0.04	-0.04
Unemployment rate (% of labour force)	0.34	0.46	0.44	0.36	0.27	0.18	0.04	0.04	0.03
Output gap (% GDP)	-0.97	-0.58	-0.23	-0.02	0.08	0.11	0.02	0.00	0.00

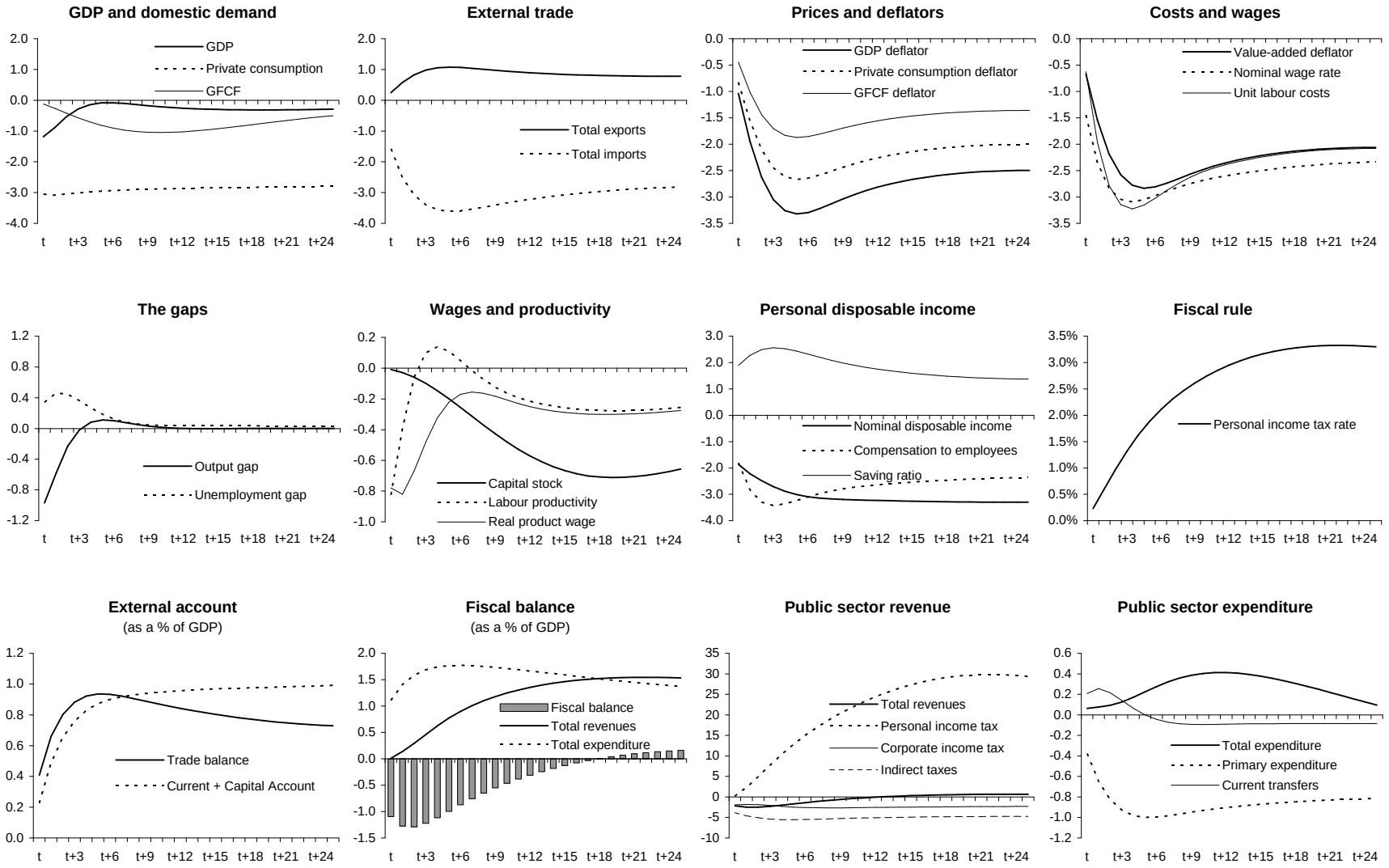

Figure 3. Permanent 50 b.p. increase in risk premium

The fiscal balance deteriorates considerably in the short run, though the increase in the income tax rate will re-equilibrate the fiscal balance in the long-run.

The impacts of this shock are particularly interesting, as an increase in the risk premium in a small open economy may occur whenever large fiscal and external imbalances are witnessed. However, in the case of an economy, such as Portugal's, integrated in a monetary union, this kind of adjustment is not so likely.

4.3 Exchange rate shock

The exchange rate shock corresponds to a permanent 5% appreciation in the effective exchange rate of the euro. This translates into a permanent 1.5% appreciation in the effective exchange rate of Portugal, since trade with countries outside the euro area accounts for around one third of the Portuguese external trade (if energy goods are excluded).

It should be noted that this simulation does not consider the indirect impacts stemming from the euro appreciation on economic activity of Portugal's main trading partners, and this is likely to affect their demand for Portuguese exports. Thus, the impacts presented in Table 5 and in Figure 4 in economic activity and, particularly, in exports are likely to be somewhat underestimated.

The appreciation of the effective exchange rate of the euro has a direct and immediate impact on external trade deflators. This model assumes that in a small open economy, importers act as price-takers in international goods markets and so there is a complete pass-through of the exchange rate appreciation to import prices. [20] Portuguese exporters are assumed to behave slightly different, since they combine domestic goods with imported goods and, thus, any change in domestic production costs must be reflected in the price of exports, in line with the domestic value-added content of Portuguese exports. This behaviour of external trade deflators determines that an appreciation of the effective exchange rate leads to a short-run improvement in terms of trade as the pass-through to exports deflators is not complete in the short run.

The price formation mechanism of final goods retailers determines that the pass-through of the exchange rate appreciation to the final demand deflators (namely, private consumption, government consumption, investment and exports deflators) is reasonably fast. However, domestic output prices and wages are sticky in the short run, determining that the impact of the appreciation leads to considerable competitiveness losses and to the deterioration of trade balance, reflecting the increase in imports and the decline in exports. This short-run decline in the demand for domestic production translates into excess supply and into an increase in unemployment, driving wages and unit labour costs downwards and restoring competitiveness conditions to the Portuguese economy.

[20] Excluding energy goods, whose price is assumed to be fixed in US dollars.

Table 5. Permanent 5% appreciation in the effective exchange rate of the euro

	t	*t+1*	*t+2*	*t+3*	*t+4*	*t+5*	*t+10*	*t+15*	*t+20*
Prices and costs									
HICP	-0.62	-0.94	-1.19	-1.35	-1.45	-1.49	-1.49	-1.49	-1.50
Energy	-0.38	-0.74	-1.02	-1.21	-1.31	-1.36	-1.36	-1.36	-1.37
Non-Energy	-0.64	-0.96	-1.20	-1.37	-1.46	-1.51	-1.50	-1.50	-1.51
GDP deflator	-0.42	-0.82	-1.13	-1.34	-1.46	-1.52	-1.51	-1.51	-1.52
Private consumption deflator	-0.62	-0.94	-1.19	-1.35	-1.45	-1.49	-1.49	-1.49	-1.50
GFCF deflator	-0.82	-1.07	-1.26	-1.38	-1.46	-1.49	-1.49	-1.49	-1.49
ULC, whole economy	-0.35	-0.97	-1.35	-1.53	-1.59	-1.59	-1.47	-1.48	-1.49
Compensation per employee	-0.70	-1.13	-1.36	-1.47	-1.50	-1.50	-1.46	-1.47	-1.48
Productivity, whole economy	-0.35	-0.16	-0.01	0.06	0.09	0.08	0.02	0.01	0.01
Real comp. per employee	-0.07	-0.19	-0.17	-0.11	-0.05	-0.01	0.04	0.03	0.02
Imports deflator	-1.41	-1.41	-1.41	-1.41	-1.41	-1.41	-1.41	-1.41	-1.41
Exports deflator	-0.86	-1.09	-1.27	-1.39	-1.46	-1.49	-1.49	-1.49	-1.49
Economic Activity									
(constant prices)									
Real GDP	-0.50	-0.35	-0.19	-0.07	0.00	0.03	0.02	0.01	0.01
Private consumption	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0.00
Government consumption	-0.05	-0.12	-0.11	-0.07	-0.03	0.00	0.02	0.02	0.01
GFCF	0.05	0.07	0.09	0.09	0.09	0.08	0.04	0.01	0.00
Exports (goods and services)	-0.39	-0.25	-0.14	-0.07	-0.03	-0.01	-0.01	-0.01	0.00
Imports (goods and services)	0.93	0.53	0.29	0.14	0.05	0.01	0.00	-0.01	-0.02
Domestic demand	0.02	0.03	0.04	0.06	0.07	0.07	0.06	0.04	0.03
Changes in inventories	0.05	-0.02	-0.02	-0.01	0.00	0.01	0.00	0.00	0.00
Net exports	-0.59	-0.36	-0.21	-0.12	-0.06	-0.04	-0.03	-0.03	-0.02
Disposable household income	-0.78	-0.98	-1.13	-1.25	-1.34	-1.42	-1.60	-1.70	-1.76
Compensation to employees	-0.84	-1.32	-1.54	-1.60	-1.59	-1.55	-1.45	-1.47	-1.48
Household saving ratio	-0.18	-0.07	0.03	0.07	0.07	0.04	-0.12	-0.20	-0.24
Trade balance (% GDP)	-0.26	-0.16	-0.10	-0.06	-0.04	-0.04	-0.03	-0.03	-0.03
Curr. + cap. account (% GDP)	-0.25	-0.16	-0.10	-0.07	-0.05	-0.04	-0.04	-0.03	-0.03
Fiscal Developments									
(as a % of GDP)									
Total receipts	0.12	0.15	0.19	0.23	0.27	0.31	0.43	0.48	0.51
Total expenditures	0.36	0.43	0.47	0.50	0.52	0.52	0.52	0.52	0.50
Balance	-0.25	-0.28	-0.29	-0.27	-0.24	-0.21	-0.10	-0.04	0.00
Primary expenditure	0.33	0.38	0.41	0.43	0.44	0.44	0.44	0.44	0.44
Govt. primary budget balance	-0.21	-0.23	-0.22	-0.20	-0.16	-0.13	-0.01	0.04	0.07
Gross Debt	0.78	1.17	1.49	1.75	1.93	2.06	2.21	1.97	1.59
Supply and labour market conditions									
Capital stock	0.00	0.01	0.02	0.02	0.03	0.03	0.04	0.03	0.02
Total employment	-0.15	-0.20	-0.18	-0.14	-0.09	-0.05	0.01	0.00	0.00
Unemployment rate (% of labour force)	0.14	0.18	0.17	0.13	0.09	0.05	-0.01	0.00	0.00
Output gap (% GDP)	-0.41	-0.24	-0.09	0.00	0.04	0.05	0.01	0.00	0.00

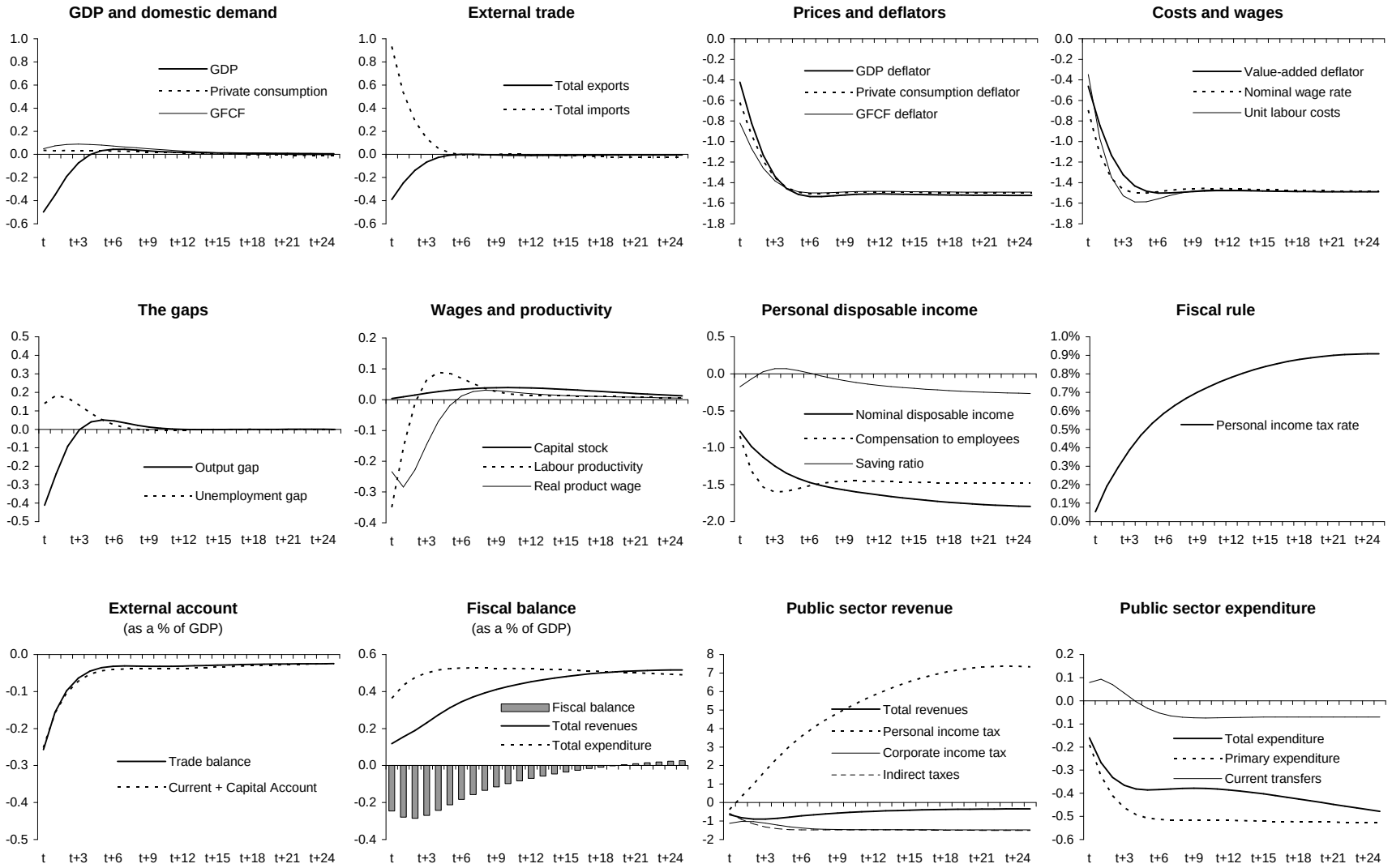

Figure 4. Permanent 5% appreciation in the effective exchange rate of the euro

In the long run, domestic output prices and wages fall to adjust to excess supply conditions recorded in the meantime. Real GDP reverts to its baseline level and expenditure composition also remains unchanged, reflecting the fact that exchange rate shocks are long-run neutral in terms of output and expenditure composition. This simulation illustrates the fact that expenditure composition depends on the relative prices of final demand components and not on absolute price levels.

In terms of the trade balance, the so-called J-curve effect can be observed since, in the short run, the effective appreciation primarily leads to a sizeable increase in import volume and to a smaller decline in export volume. As mentioned above, terms of trade improve in the short run due to the price formation mechanism of importers and exporters, leading to a faster pass-through of the exchange rate into imports deflator. However, in the long run, the adjustment of domestic output prices and wages drives export and import volumes and terms of trade back to their baseline levels, determining that there are no long-run impacts in the trade balance to GDP ratio.

The government primary fiscal balance deteriorates as a result of the exchange rate appreciation. The decline in prices and wages have a negative impact in both fiscal revenues and government primary expenditure, however this decrease is smaller than the decline in nominal GDP, determining an increase if these aggregates are expressed as a percentage of GDP (see Table 5). However, in the short-run, the fall in fiscal revenues is bigger than the decrease in government primary expenditure, mainly due to the increase in unemployment and the corresponding higher expenditure in unemployment benefits.

4.4 Technology shock

The technology shock consists in simulating a permanent 1% increase in Portuguese total factor productivity. Table 6 and Figure 5 illustrate the impact of this shock.

The increase in total factor productivity corresponds to an increase in labour augmenting productivity, leading to an upward adjustment in nominal and real wages throughout the simulation period. However, the increase in nominal wages is smaller than the increase in labour productivity, determining a significant decline in unit labour costs and, therefore, in domestic output prices. The decline in domestic production costs spreads across final demand deflators, according to the domestic value-added content of each one. In the short run, profit margins increase as domestic output prices adjust faster than nominal wages; however, in the long run, profit margins revert to their baseline level, keeping the capital-income share unchanged. [21]

Real GDP jumps immediately, reflecting the forward-looking behaviour of both households

[21] This result reflects one of the distintive features of the Cobb-Douglas production function. An alternative formulation for the production function could have led to different results, however empirical evidence shoes that it has been fairly stable in Portugal during the last decade.

Table 6. Permanent increase of 1% in total factor productivity

	t	*t+1*	*t+2*	*t+3*	*t+4*	*t+5*	*t+10*	*t+15*	*t+20*
Prices and costs									
HICP	-0.23	-0.32	-0.38	-0.41	-0.44	-0.46	-0.61	-0.75	-0.83
Energy	-0.26	-0.36	-0.42	-0.46	-0.49	-0.52	-0.68	-0.84	-0.94
Non-Energy	-0.22	-0.32	-0.37	-0.41	-0.43	-0.46	-0.60	-0.74	-0.82
GDP deflator	-0.28	-0.40	-0.47	-0.51	-0.55	-0.58	-0.76	-0.94	-1.04
Private consumption deflator	-0.23	-0.32	-0.38	-0.41	-0.44	-0.46	-0.61	-0.75	-0.83
GFCF deflator	-0.21	-0.30	-0.34	-0.36	-0.38	-0.39	-0.50	-0.61	-0.67
ULC, whole economy	-0.75	-0.58	-0.56	-0.56	-0.57	-0.58	-0.74	-0.92	-1.03
Compensation per employee	0.29	0.41	0.47	0.52	0.55	0.58	0.58	0.52	0.47
Productivity, whole economy	1.05	0.99	1.04	1.09	1.13	1.16	1.33	1.46	1.51
Real comp. per employee	0.52	0.73	0.85	0.93	1.00	1.04	1.20	1.28	1.31
Imports deflator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports deflator	-0.20	-0.28	-0.32	-0.34	-0.36	-0.37	-0.47	-0.57	-0.64
Economic Activity									
(constant prices)									
Real GDP	1.05	0.98	1.03	1.09	1.14	1.18	1.34	1.46	1.51
Private consumption	1.08	1.09	1.09	1.09	1.09	1.09	1.11	1.13	1.15
Government consumption	0.34	0.47	0.55	0.60	0.64	0.67	0.77	0.82	0.84
GFCF	0.33	0.62	0.88	1.10	1.27	1.41	1.68	1.57	1.36
Exports (goods and services)	0.12	0.17	0.19	0.20	0.21	0.22	0.28	0.35	0.38
Imports (goods and services)	0.61	0.21	0.16	0.18	0.20	0.21	0.14	-0.02	-0.14
Domestic demand	0.87	0.96	1.03	1.08	1.13	1.16	1.23	1.20	1.11
Changes in inventories	0.45	0.08	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Net exports	-0.24	-0.04	0.00	0.00	0.00	0.00	0.10	0.25	0.39
Disposable household income	0.91	0.63	0.61	0.62	0.62	0.63	0.59	0.51	0.45
Compensation to employees	0.29	0.40	0.47	0.52	0.56	0.59	0.60	0.53	0.47
Household saving ratio	0.06	-0.12	-0.09	-0.05	-0.02	0.00	0.09	0.13	0.13
Trade balance (% GDP)	-0.20	-0.08	-0.07	-0.07	-0.08	-0.09	-0.07	-0.03	0.01
Curr. + cap. account (% GDP)	-0.20	-0.09	-0.08	-0.09	-0.10	-0.11	-0.11	-0.08	-0.05
Fiscal Developments									
(as a % of GDP)									
Total receipts	-0.10	-0.05	-0.05	-0.07	-0.08	-0.10	-0.16	-0.18	-0.18
Total expenditures	-0.32	-0.22	-0.21	-0.21	-0.21	-0.22	-0.21	-0.18	-0.15
Balance	0.22	0.17	0.15	0.14	0.13	0.12	0.05	0.00	-0.02
Primary expenditure	-0.29	-0.19	-0.17	-0.17	-0.17	-0.18	-0.16	-0.14	-0.13
Govt. primary budget balance	0.19	0.14	0.12	0.11	0.09	0.08	0.01	-0.04	-0.05
Gross Debt	-0.66	-0.69	-0.80	-0.91	-1.01	-1.09	-1.19	-0.98	-0.67
Supply and labour market conditions									
Capital stock	0.03	0.07	0.13	0.21	0.29	0.38	0.82	1.11	1.24
Total employment	0.00	-0.01	-0.01	0.00	0.01	0.01	0.01	0.00	0.00
Unemployment rate (% of labour force)	0.00	0.01	0.01	0.00	-0.01	-0.01	-0.01	0.00	0.00
Output gap (% GDP)	0.04	-0.04	-0.02	0.00	0.01	0.01	0.00	0.00	0.00

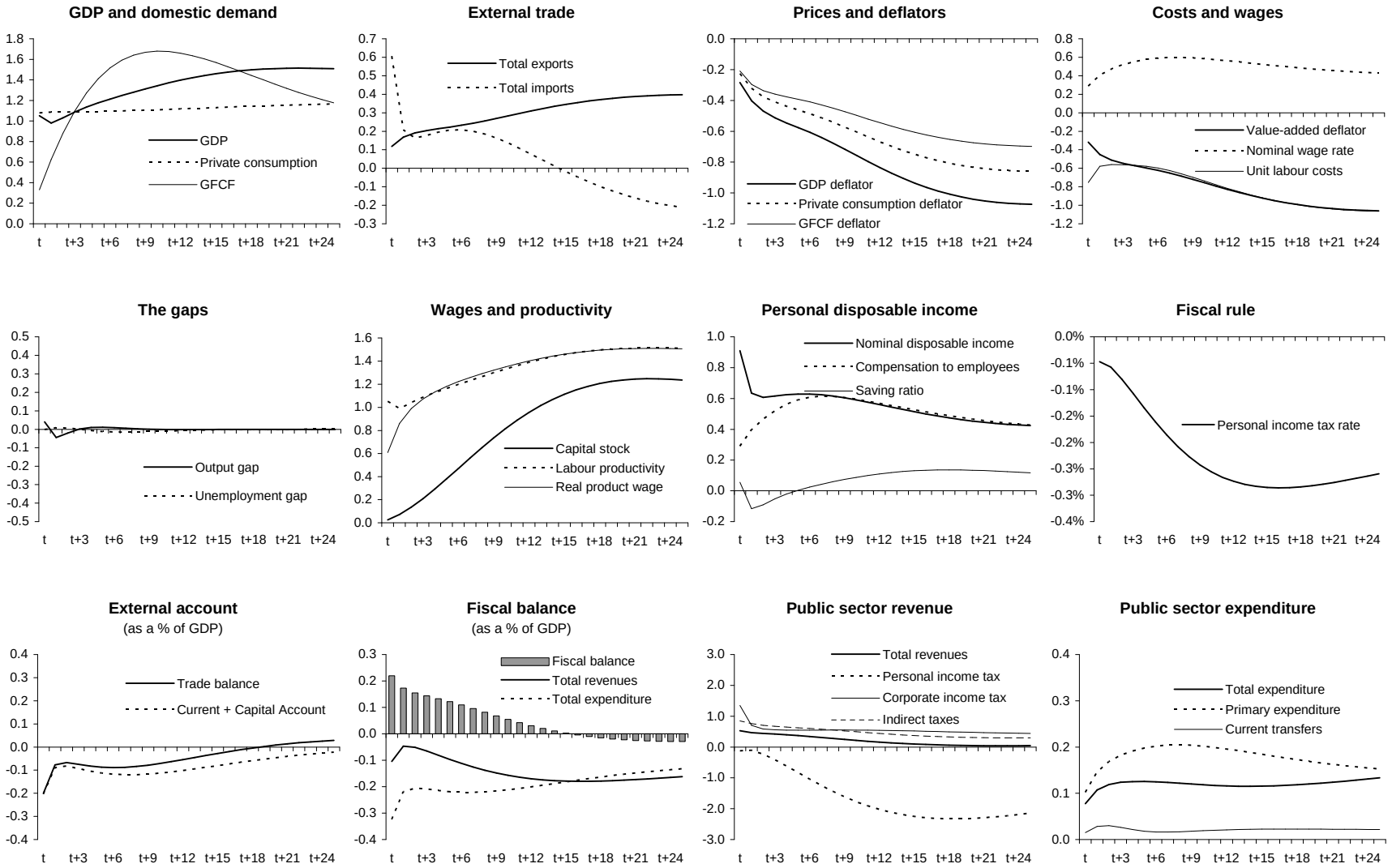

Figure 5. Permanent increase of 1% in total factor productivity

an firms. Private consumption increases permanently as a result of the increase in real wages and the decline in the income tax rate. GFCF also increases reflecting an upward adjustment of the capital stock level, responding to the increase potential output, in order to keep capital-output ratio constant. In the short run, the increase in potential output also leads to a significant contribution of changes in inventories to GDP growth, reflecting not only the close link between optimal inventories level and output, but also the role of stock building in cushioning sudden changes in output gap.

In terms of external trade, the technology shock leads to a short-run deterioration of the trade balance. This impact stems from the significant increase in imports volume, that is being driven both by private consumption and investment; however, the downward adjustment in domestic output prices favours the substitution of imported goods by domestic output. Exports volume increases significantly due to the improvement in competitiveness conditions, namely the decline in unit labour costs that translates into a decrease in the exports deflator. In the long run, trade balance (as a percentage of GDP) returns to its baseline level.

The fiscal balance improves considerably in the short run as a result of the increase in nominal wages and in private consumption and real GDP, despite the decline in prices. Fiscal revenues increase in absolute terms due to higher corporate income tax and indirect tax revenues; government primary expenditure also increases, in absolute terms, mainly reflecting the upward adjustment in nominal wages. However, both revenue and expenditure fall as a percentage of GDP. The fiscal rule ensures that income tax rate is adjusted downwards and that fiscal balance reverts to its baseline level in the long-run.

5 The fiscal policy shocks

As previously mentioned, the model presented in this paper was also designed to simulate a set of fiscal policy shocks. Since the model includes economic agents that form model consistent expectations, the impact of fiscal policy shocks depends crucially on the timing of the shock and on its persistence.

The macroeconomic model previously presented includes a disaggregated public sector account. In fact, the transmission channels from fiscal policy shocks to the rest of the economy can only be accounted for properly if public sector expenditures and revenues are sufficiently disaggregated. The transmission mechanism of these shocks is of major interest, since it tells the story of the shock from its direct impacts to the second round effects.

Fiscal policy shocks are assumed to be permanent, meaning that government performs once for all changes in the policy instruments under consideration. Additionally, it is also assumed that the shocks are not anticipated, that is, economic agents only observe the

shocks when they effectively occur. [22] The fiscal shocks are implemented by permanently changing the fiscal parameters and variables.

In this context the following shocks are simulated:

(1) an employees' social security contributions shock;
(2) a corporate income tax shock;
(3) a public sector employment shock;
(4) a civil servants' wage scale shock.

Additionally, it must be clear that the fiscal policy rule is still active, meaning that any fiscal policy shock will lead to an automatic change in the personal income tax rate in order to ensure the fulfilment of the fiscal requirements. The fiscal rule and the forward-looking behaviour of economic agents embed some Ricardian features in the model, since economic agents foresee increases and decreases in their income tax payments in line with the budgetary situation.

5.1 Employees' social security contributions shock

The social security contributions shock consists of a permanent 1 percentage point (p.p.) increase in the implicit average rate of social security contributions, without any adjustment in nominal wages. [23] The simulation results are presented in Table 7 and in Figure 6.

An increase in employees' social security contributions without any adjustment in nominal wages corresponds to a decline in household disposable income. However, economic agents (specially consumers) foresee a corresponding decline in the personal income tax rate, anticipating that the decline in their disposable income is just temporary.

As households utility maximisation determine a consumption smoothing behaviour, the short-run adjustment to the decline in disposable income implies a marginal downward adjustment in private consumption and a significant fall in the saving ratio. GDP also declines marginally as the decline in imports partially offsets the decline in private consumption.

In the long run, as the personal income tax rate declines and household disposable income reverts to the baseline, the saving ratio and private consumption also converge to the baseline. Thus, the previous short-run impact in GDP and in imports will also be reverted,

[22] This is a quite stringent assumption in the context of a quarterly model, though in the case of an annual model it seems more reasonable. On the contrary, it is quite implausible that any government would announce the fiscal policy measures one year before implementing them on a regular basis.
[23] The baseline implicit average rate for overall social security contributions is 24.5%, thus this shock consists of an increase of around 4 per cent in the average rate.

Table 7. Permanent 1 p.p. increase in the average rate of social security contributions

	t	*t+1*	*t+2*	*t+3*	*t+4*	*t+5*	*t+10*	*t+15*	*t+20*
Prices and costs									
HICP	-0.04	-0.07	-0.10	-0.11	-0.12	-0.12	-0.09	-0.06	-0.04
Energy	-0.04	-0.08	-0.11	-0.13	-0.14	-0.14	-0.10	-0.07	-0.05
Non-Energy	-0.04	-0.07	-0.10	-0.11	-0.12	-0.12	-0.09	-0.06	-0.04
GDP deflator	-0.05	-0.09	-0.12	-0.14	-0.15	-0.15	-0.12	-0.08	-0.06
Private consumption deflator	-0.04	-0.07	-0.10	-0.11	-0.12	-0.12	-0.09	-0.06	-0.04
GFCF deflator	-0.02	-0.05	-0.07	-0.08	-0.08	-0.09	-0.06	-0.04	-0.03
ULC, whole economy	-0.03	-0.10	-0.13	-0.15	-0.15	-0.15	-0.10	-0.07	-0.05
Compensation per employee	-0.07	-0.11	-0.14	-0.15	-0.15	-0.14	-0.11	-0.09	-0.06
Productivity, whole economy	-0.04	-0.02	0.00	0.00	0.00	0.00	-0.01	-0.02	-0.02
Real comp. per employee	-0.03	-0.04	-0.04	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02
Imports deflator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports deflator	-0.02	-0.05	-0.06	-0.08	-0.08	-0.08	-0.06	-0.04	-0.03
Economic Activity									
(constant prices)									
Real GDP	-0.06	-0.04	-0.03	-0.02	-0.01	-0.01	-0.02	-0.02	-0.02
Private consumption	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.12	-0.10	-0.08
Government consumption	-0.02	-0.03	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01
GFCF	-0.01	-0.03	-0.04	-0.05	-0.06	-0.07	-0.07	-0.05	-0.03
Exports (goods and services)	0.01	0.03	0.04	0.05	0.05	0.05	0.04	0.02	0.02
Imports (goods and services)	-0.08	-0.12	-0.15	-0.17	-0.17	-0.17	-0.14	-0.10	-0.07
Domestic demand	-0.10	-0.11	-0.11	-0.11	-0.12	-0.12	-0.12	-0.11	-0.10
Changes in inventories	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net exports	0.04	0.07	0.09	0.10	0.11	0.11	0.11	0.09	0.08
Disposable households income	-0.95	-0.92	-0.89	-0.86	-0.83	-0.79	-0.58	-0.41	-0.29
Compensation to employees	-0.09	-0.14	-0.16	-0.16	-0.16	-0.15	-0.12	-0.09	-0.06
Household saving ratio	-0.72	-0.66	-0.61	-0.57	-0.53	-0.50	-0.35	-0.23	-0.15
Trade balance (% GDP)	0.02	0.03	0.04	0.04	0.04	0.04	0.04	0.03	0.02
Curr. + cap. account (% GDP)	0.02	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.04
Fiscal Developments									
(as a % of GDP)									
Total receipts	0.45	0.41	0.37	0.34	0.30	0.27	0.13	0.03	-0.03
Total expenditures	0.02	0.01	0.01	0.00	-0.01	-0.02	-0.06	-0.07	-0.07
Balance	0.43	0.39	0.36	0.34	0.31	0.29	0.19	0.10	0.04
Primary expenditure	0.04	0.05	0.05	0.05	0.05	0.05	0.04	0.03	0.02
Govt. primary budget balance	0.41	0.36	0.32	0.28	0.25	0.22	0.09	0.00	-0.05
Gross Debt	-0.37	-0.73	-1.05	-1.34	-1.58	-1.80	-2.42	-2.48	-2.22
Supply and labour market conditions									
Capital stock	0.00	0.00	-0.01	-0.01	-0.01	-0.02	-0.04	-0.04	-0.04
Total employment	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	0.00	0.00	0.00
Unemployment rate (% of labour force)	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.00
Output gap (% GDP)	-0.04	-0.03	-0.01	0.00	0.00	0.00	0.00	0.00	0.00

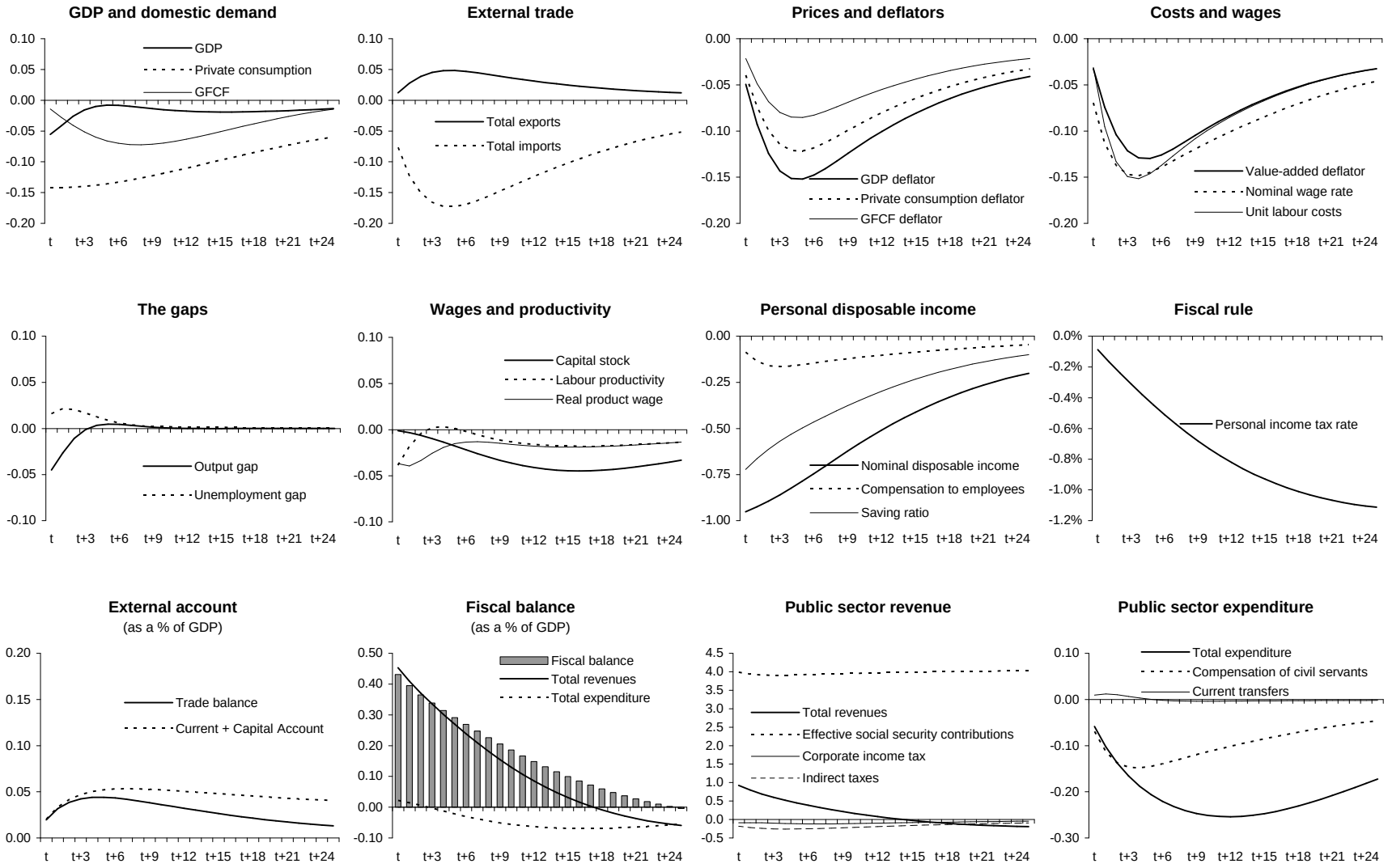

Figure 6. Permanent 1 p.p. increase in the average rate of social security contributions

determining that the impact of this shock is neutral in terms of economic activity and in terms of final demand composition. However, the results presented in Table 7 and in Figure 6 show that disposable income has not reverted to the baseline after 20 years. This slow reversion is related to the smoothness of the fiscal policy rule,[24] determining a slow convergence in public debt; as public debt belongs to households' asset wealth, this affects private consumption level reversion.

The long-run impact of this shock on prices and wages is negligible and labour market variables are not sensitive to this type of shock. The trade balance exhibits a marginal improvement, reflecting the decline in import demand due to the short-run decrease in domestic demand; however, in the long run, this shock does not affect the external accounts.

The fiscal balance improves in the short run, since revenues increase and expenditures remain almost unchanged (as a % of GDP). As the government adjusts personal income tax rate downwards, according to the fiscal rule, the balance returns to its baseline level.

The simulation of this shock illustrates the fact that from a macroeconomic perspective, personal income taxes and employees' social security contributions are two sides of the same coin, in the sense that both affect households in the same way. However, it should be mentioned that the distribution of the tax burden across taxpayers can be significantly different, but this is beyond the scope of this paper.

5.2 Corporate income tax shock

The corporate income tax shock consists of a 1 p.p. permanent increase in the average corporate income tax rate.[25] Table 8 and Figure 7 illustrate the impact of the shock on macroeconomic variables.

A permanent increase in corporate income tax rate has a direct impact on the relevant rate of return of capital, determining a permanent decline in the optimal capital stock. The subsequent downward adjustment in the capital stock leads to a permanent decline in potential output. Therefore, the fall in the rate of return of capital translates into a decrease in households' asset wealth, reflecting the decline in the capital stock, and permanently depressing private consumption through the wealth channel. Additionally, the decline in potential output also determines a decline in labour demand and in nominal wages and a negative impact on disposable income, provoking, therefore, a further de-

[24] However, if fiscal policy rule adjustment parameters were calibrated to ensure a faster adjustment, then unreliable dynamic features would arise, in particular very marked cyclical behaviour in income tax and this would be translated into disposable income, private consumption and GDP.

[25] The average rate implicit in the baseline is 8%, thus this shock increases the average tax rate by 12.5%.

Table 8. Permanent increase of 1 p.p. in the corporate income tax rate

	t	*t+1*	*t+2*	*t+3*	*t+4*	*t+5*	*t+10*	*t+15*	*t+20*
Prices and costs									
HICP	-0.19	-0.34	-0.45	-0.50	-0.51	-0.48	-0.13	0.16	0.32
Energy	-0.21	-0.39	-0.50	-0.56	-0.57	-0.54	-0.15	0.18	0.36
Non-Energy	-0.18	-0.34	-0.44	-0.50	-0.50	-0.47	-0.13	0.16	0.32
GDP deflator	-0.23	-0.43	-0.56	-0.63	-0.63	-0.60	-0.17	0.20	0.40
Private consumption deflator	-0.19	-0.34	-0.45	-0.50	-0.51	-0.48	-0.13	0.16	0.32
GFCF deflator	-0.12	-0.24	-0.33	-0.38	-0.38	-0.36	-0.11	0.12	0.24
ULC, whole economy	-0.20	-0.50	-0.68	-0.74	-0.73	-0.67	-0.19	0.17	0.37
Compensation per employee	-0.37	-0.62	-0.77	-0.85	-0.88	-0.88	-0.70	-0.52	-0.40
Productivity, whole economy	-0.17	-0.12	-0.10	-0.11	-0.15	-0.21	-0.51	-0.70	-0.76
Real comp. per employee	-0.18	-0.28	-0.33	-0.35	-0.38	-0.40	-0.57	-0.69	-0.72
Imports deflator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports deflator	-0.11	-0.23	-0.31	-0.36	-0.36	-0.34	-0.10	0.11	0.22
Economic Activity									
(constant prices)									
Real GDP	-0.25	-0.23	-0.21	-0.21	-0.24	-0.27	-0.53	-0.70	-0.76
Private consumption	-0.53	-0.53	-0.52	-0.52	-0.51	-0.50	-0.48	-0.46	-0.43
Government consumption	-0.12	-0.18	-0.21	-0.23	-0.24	-0.26	-0.37	-0.44	-0.46
GFCF	-0.52	-0.99	-1.40	-1.75	-2.02	-2.24	-2.57	-2.32	-1.97
Exports (goods and services)	0.07	0.14	0.19	0.21	0.22	0.21	0.06	-0.07	-0.13
Imports (goods and services)	-0.44	-0.74	-0.93	-1.05	-1.11	-1.12	-0.87	-0.53	-0.29
Domestic demand	-0.49	-0.62	-0.72	-0.80	-0.87	-0.93	-1.09	-1.09	-1.02
Changes in inventories	0.01	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.02
Net exports	0.23	0.41	0.53	0.61	0.66	0.68	0.58	0.39	0.25
Disposable household income	-0.88	-0.99	-1.05	-1.08	-1.07	-1.04	-0.68	-0.31	-0.04
Compensation to employees	-0.45	-0.73	-0.89	-0.96	-0.97	-0.95	-0.72	-0.53	-0.40
Household saving ratio	-0.16	-0.11	-0.08	-0.06	-0.05	-0.06	-0.06	-0.01	0.07
Trade balance (% GDP)	0.12	0.20	0.26	0.29	0.31	0.32	0.27	0.18	0.11
Curr. + cap. account (% GDP)	0.12	0.21	0.28	0.32	0.35	0.37	0.38	0.33	0.28
Fiscal Developments									
(as a % of GDP)									
Total receipts	0.33	0.33	0.33	0.34	0.34	0.34	0.29	0.21	0.13
Total expenditures	0.18	0.22	0.25	0.26	0.27	0.26	0.18	0.10	0.04
Balance	0.15	0.11	0.08	0.07	0.07	0.08	0.11	0.11	0.09
Primary expenditure	0.17	0.22	0.25	0.26	0.27	0.26	0.20	0.14	0.10
Govt. primary budget balance	0.16	0.11	0.09	0.07	0.07	0.07	0.09	0.07	0.03
Gross Debt	0.12	0.12	0.10	0.06	0.00	-0.08	-0.61	-1.10	-1.38
Supply and labour market conditions									
Capital stock	-0.04	-0.11	-0.21	-0.33	-0.46	-0.60	-1.27	-1.70	-1.85
Total employment	-0.08	-0.11	-0.12	-0.10	-0.09	-0.07	-0.02	0.00	0.00
Unemployment rate (% of labour force)	0.07	0.11	0.11	0.10	0.08	0.06	0.02	0.00	0.00
Output gap (% GDP)	-0.19	-0.12	-0.06	-0.02	0.01	0.01	0.01	0.00	0.00

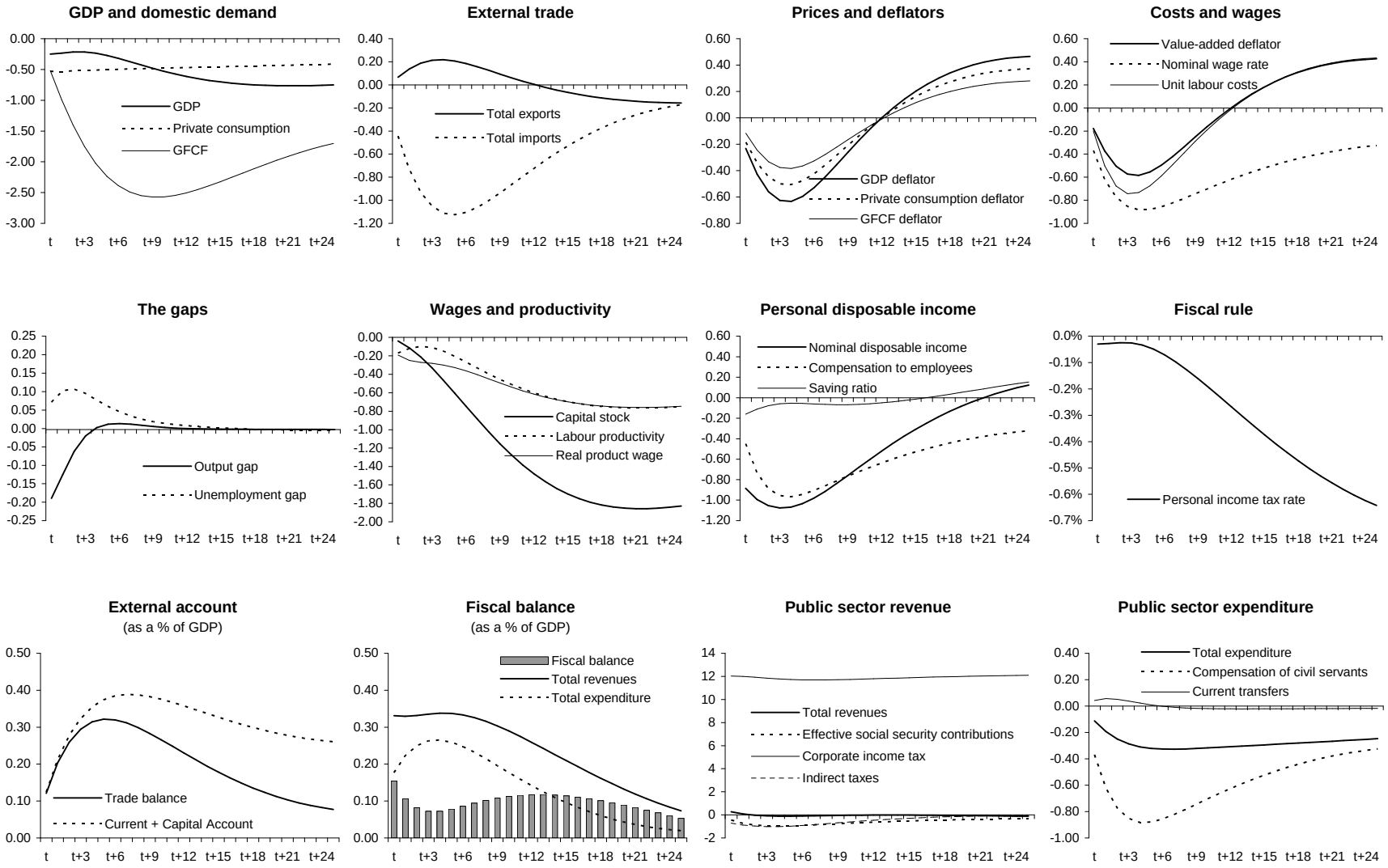

Figure 7. Permanent increase of 1 p.p. in the corporate income tax rate

cline in private consumption through the income channel. GFCF also falls significantly, reflecting the downward adjustment of the capital stock.

The simulation of this shock shows that contrary to the social contributions shock presented above, an increase in the corporate income tax rate has a permanent negative impact on economic activity, with a negative effect on the rate of return on capital and the potential output of the economy. In the short run, the decline in final demand is stronger than the fall in potential output, determining excess supply conditions, and this will drive prices and wages downwards. However, as personal income tax declines and disposable income reverts to the baseline level, private consumption and GFCF revert partially, absorbing the excess supply and determining an upturn in prices.

The decline in private consumption and GFCF is the main driving force behind final demand behaviour. Additionally, the downward adjustment in nominal wages also determines a decline in government consumption, deepening the decline in domestic demand. [26] Notwithstanding, the increase in the unemployment rate is largely temporary, since the downward adjustment in nominal wages will restore private sector labour demand to its baseline level.

In terms of external trade, this shock improves the trade balance (as a % of GDP) in the short run, since the fall in domestic demand will have a significant negative impact on imports and the decline in the domestic output deflator will favour the substitution of imported goods by domestic output. As prices revert, the trade balance (as a % of GDP) converges to its baseline level, reflecting the dissipation of the temporarily favourable competitiveness conditions.

The fiscal balance is benefited by this increase in corporate income tax, improving at around 0.1% of GDP. In the long run, this improvement will be fully offset by the decline in personal income tax. As in the previous shock, the smooth behaviour of the fiscal rule hinders the interpretation of the impact on fiscal variables presented in Table 8 and Figure 7. [27]

5.3 Public sector employment shock

The public sector employment shock consists of simulating a permanent 1% increase in the number of civil servants. This is the typical government consumption shock, since its volume is to a large extent influenced by the number of civil servants. [28] Table 9 and Figure 8 present the simulation results.

[26] It is worth in mentioning that public sector wage bill account for around 80% of government consumption expenditures.
[27] See subsection 5.1 for a more detailed description of the problem
[28] As previously referred public sector wage bill account for around 80% of government consumption expenditures.

Table 9. Permanent increase of 1% in public sector employment

	t	*t+1*	*t+2*	*t+3*	*t+4*	*t+5*	*t+10*	*t+15*	*t+20*
Prices and costs									
HICP	0.02	0.05	0.07	0.08	0.08	0.08	0.06	0.04	0.02
Energy	0.03	0.05	0.07	0.09	0.09	0.09	0.07	0.04	0.03
Non-Energy	0.02	0.05	0.06	0.08	0.08	0.08	0.06	0.04	0.02
GDP deflator	0.03	0.06	0.08	0.10	0.10	0.10	0.07	0.05	0.03
Private consumption deflator	0.02	0.05	0.07	0.08	0.08	0.08	0.06	0.04	0.02
GFCF deflator	0.04	0.06	0.07	0.08	0.08	0.08	0.07	0.05	0.04
ULC, whole economy	0.04	0.09	0.13	0.14	0.14	0.14	0.10	0.08	0.06
Compensation per employee	0.07	0.11	0.13	0.14	0.14	0.14	0.12	0.10	0.08
Productivity, whole economy	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.02
Real comp. per employee	0.04	0.06	0.07	0.06	0.06	0.06	0.06	0.06	0.06
Imports deflator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports deflator	0.03	0.05	0.07	0.07	0.08	0.08	0.06	0.05	0.04
Economic Activity									
(constant prices)									
Real GDP	0.04	0.03	0.02	0.01	0.01	0.01	0.02	0.02	0.02
Private consumption	-0.10	-0.10	-0.11	-0.11	-0.11	-0.11	-0.12	-0.14	-0.15
Government consumption	0.68	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.68
GFCF	0.01	0.03	0.04	0.05	0.06	0.07	0.07	0.06	0.04
Exports (goods and services)	-0.02	-0.03	-0.04	-0.04	-0.05	-0.05	-0.04	-0.03	-0.02
Imports (goods and services)	0.03	0.06	0.08	0.09	0.10	0.10	0.07	0.05	0.03
Domestic demand	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.07
Changes in inventories	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net exports	-0.02	-0.04	-0.06	-0.06	-0.07	-0.07	-0.07	-0.06	-0.05
Disposable household income	0.08	0.07	0.07	0.06	0.05	0.04	-0.04	-0.10	-0.16
Compensation to employees	0.08	0.13	0.15	0.15	0.15	0.15	0.12	0.10	0.08
Household saving ratio	0.15	0.12	0.10	0.09	0.07	0.07	0.03	0.00	-0.03
Trade balance (% GDP)	0.00	-0.01	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	0.00
Curr. + cap. account (% GDP)	0.00	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01
Fiscal Developments									
(as a % of GDP)									
Total receipts	-0.01	0.01	0.02	0.03	0.04	0.05	0.09	0.13	0.15
Total expenditures	0.13	0.13	0.13	0.13	0.14	0.14	0.16	0.16	0.17
Balance	-0.14	-0.12	-0.11	-0.10	-0.10	-0.09	-0.06	-0.04	-0.02
Primary expenditure	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.14
Govt. primary budget balance	-0.13	-0.11	-0.10	-0.09	-0.08	-0.07	-0.03	-0.01	0.01
Gross Debt	0.10	0.20	0.30	0.38	0.46	0.53	0.76	0.81	0.75
Supply and labour market conditions									
Capital stock	0.00	0.00	0.01	0.01	0.01	0.02	0.04	0.05	0.05
Total employment	0.01	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00
Unemployment rate (% of labour force)	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01	0.00	0.00	0.00
Output gap (% GDP)	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00

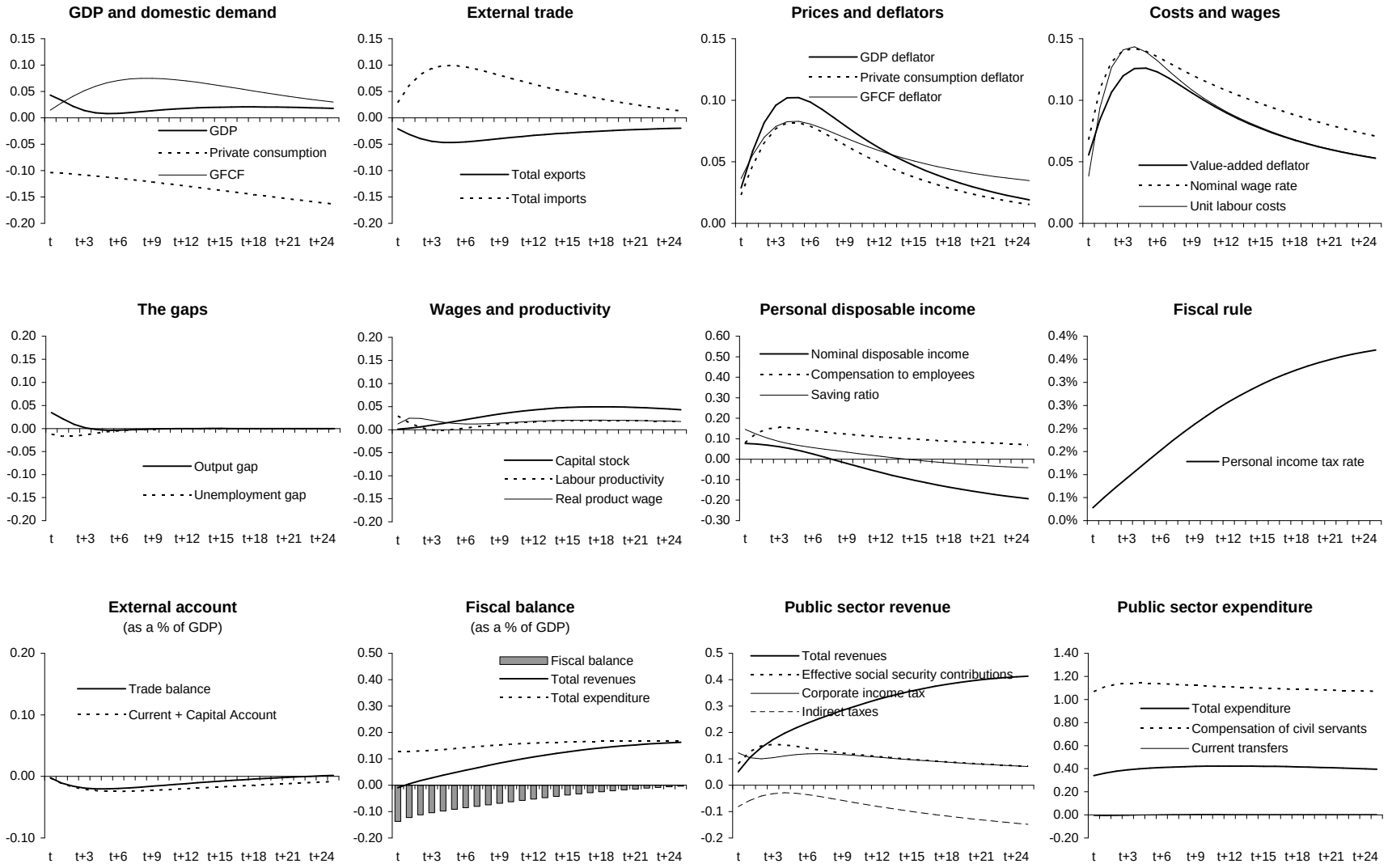

Figure 8. Permanent increase of 1% in public sector employment

A permanent increase in the number of civil servants expands aggregate demand and has two direct impacts: public consumption increases considerably; and household disposable income increases, following the upward shift in the public sector wage bill.

The increase in nominal disposable income translates into a real increase in the short run due to price and wage rigidity. Notwithstanding, private consumption falls as forward-looking households foresee an increase in the personal income tax rate to offset the rise in real disposable income. Thus, the short-run impact of the public consumption increase on global demand is partially offset by the decline in private consumption and, therefore, the impact of the shock on GDP and on the output gap is negligible.

The increased demand side pressures lead to an upward adjustment in nominal wages that is not matched by a similar increase in labour productivity driving unit labour costs upwards and, thus, domestic output prices (as measured by the GDP deflator at factor costs). The adjustment of final demand deflators lead therefore to a loss of competitiveness that will be translated into an increase in imports and a decline in exports, driving GDP to its baseline level and closing the output gap.

In the long run, after the complete adjustment in prices and wages, this shock is neutral in terms of GDP level. Expenditure composition however will be considerably affected. In particular, the increase in public consumption will be fully offset by a permanent decline in private consumption, leading to a complete crowding-out effect on economic activity. The remaining expenditure components, specifically external trade variables, will revert to their baseline levels.

Trade balance (as a % of GDP) suffers a negligible deterioration as competitiveness deteriorates; however, in the long run, it reverts to the baseline.

The fiscal balance suffers a short-run deterioration due to the permanent increase in the public sector wage bill. However, the budgetary requirements force government to follow the fiscal rule, that is, to adjust the personal income tax rate upwards, as foreseen by households. The increase in fiscal revenues ensure the return of the fiscal balance to the baseline in the long run.

The government consumption shock illustrates the long-run Ricardian features of the model. As economic agents anticipate that the current increase in public expenditure and in public debt corresponds to future taxes, they act as if their wealth has in fact declined, despite the increase in their public debt holdings. The short-run behaviour of households is similar to an immediate increase in personal income tax, so they are not subject to fiscal illusion. However, it should be mentioned that it is being implicitly assumed that consumers are not liquidity constrained, which is not necessarily a realistic assumption, particularly in a country like Portugal with high indebtedness levels.

5.4 A shock on civil servants' wage scales

The civil servants' wage scale shock consists of a permanent 1% increase in public sector nominal wages. The impact of this shock is very similar to the previous one, since it also implies an increase of a similar amount in the public sector wage bill. However, in this case both the real wage rate and unit labour costs increase more rapidly, translating into stronger and faster wage and price adjustment, as can be seen in Table 10 and Figure 9.

The public sector nominal wage rate is an endogenous variable in the model, since it is modelled through a wage-setting rule that implies a growth in public sector nominal wages in line with what is observed in the private sector. This shock thus represents a permanent change in the relative public-private nominal wage rate relationship and is implemented as a permanently shock in the public sector wage-setting rule.

The nominal wage rate suffers a permanent upward shift, combining the heterogenous behaviour of private and public sector nominal wages. The increase in public sector wages is considerably larger than the increase in the private sector nominal wage rate, since the first reflects the direct impact of the shock, while the second results from the second-round effects on unit labour costs and on domestic output prices. In fact, the increase in public sector nominal wages leads to a short-run increase in household disposable income though households foresee an increase in personal income tax and therefore act as if taxes have increased immediately, adjusting consumption downwards (the same occurred in the previous shock).

The impacts of this shock on economic activity, final demand composition and trade balance are analogous to those recorded in the previous shock. In terms of labour market variables, this shock has no long-run impacts on employment level, nor even on its composition.

Table 10. Permanent increase of 1% in the public sector nominal wage rate

	t	*t+1*	*t+2*	*t+3*	*t+4*	*t+5*	*t+10*	*t+15*	*t+20*
Prices and costs									
HICP	0.06	0.08	0.09	0.08	0.07	0.07	0.04	0.03	0.01
Energy	0.07	0.10	0.10	0.09	0.08	0.07	0.05	0.03	0.02
Non-Energy	0.06	0.08	0.09	0.08	0.07	0.06	0.04	0.03	0.01
GDP deflator	0.08	0.11	0.11	0.10	0.09	0.08	0.05	0.03	0.02
Private consumption deflator	0.06	0.08	0.09	0.08	0.07	0.07	0.04	0.03	0.01
GFCF deflator	0.07	0.08	0.08	0.08	0.07	0.07	0.05	0.04	0.03
ULC, whole economy	0.25	0.19	0.16	0.13	0.11	0.10	0.08	0.06	0.05
Compensation per employee	0.27	0.20	0.16	0.13	0.12	0.11	0.09	0.08	0.06
Productivity, whole economy	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02
Real comp. per employee	0.21	0.11	0.07	0.05	0.04	0.04	0.05	0.05	0.05
Imports deflator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports deflator	0.06	0.08	0.08	0.07	0.07	0.06	0.05	0.04	0.03
Economic Activity									
(constant prices)									
Real GDP	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02
Private consumption	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.11	-0.12	-0.13
Government consumption	0.68	0.62	0.59	0.58	0.57	0.57	0.57	0.57	0.57
GFCF	0.01	0.02	0.04	0.04	0.05	0.06	0.06	0.05	0.03
Exports (goods and services)	-0.04	-0.05	-0.05	-0.04	-0.04	-0.04	-0.03	-0.02	-0.02
Imports (goods and services)	0.07	0.10	0.10	0.09	0.09	0.08	0.05	0.03	0.02
Domestic demand	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05
Changes in inventories	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net exports	-0.05	-0.07	-0.07	-0.07	-0.06	-0.06	-0.05	-0.04	-0.03
Disposable household income	0.06	0.08	0.07	0.06	0.05	0.03	-0.04	-0.10	-0.14
Compensation to employees	0.27	0.20	0.16	0.13	0.12	0.11	0.09	0.08	0.06
Household saving ratio	0.08	0.08	0.08	0.07	0.07	0.06	0.03	0.00	-0.02
Trade balance (% GDP)	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	0.00	0.00
Curr. + cap. account (% GDP)	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01
Fiscal Developments									
(as a % of GDP)									
Total receipts	0.01	0.01	0.01	0.02	0.03	0.04	0.08	0.11	0.13
Total expenditures	0.12	0.11	0.11	0.11	0.12	0.12	0.13	0.14	0.14
Balance	-0.11	-0.10	-0.10	-0.09	-0.09	-0.08	-0.05	-0.03	-0.01
Primary expenditure	0.12	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.12
Govt. primary budget balance	-0.11	-0.10	-0.09	-0.08	-0.07	-0.06	-0.03	0.00	0.01
Gross Debt	0.05	0.15	0.24	0.32	0.40	0.46	0.66	0.70	0.65
Supply and labour market conditions									
Capital stock	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.04	0.04
Total employment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unemployment rate (% of labour force)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Output gap (% GDP)	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

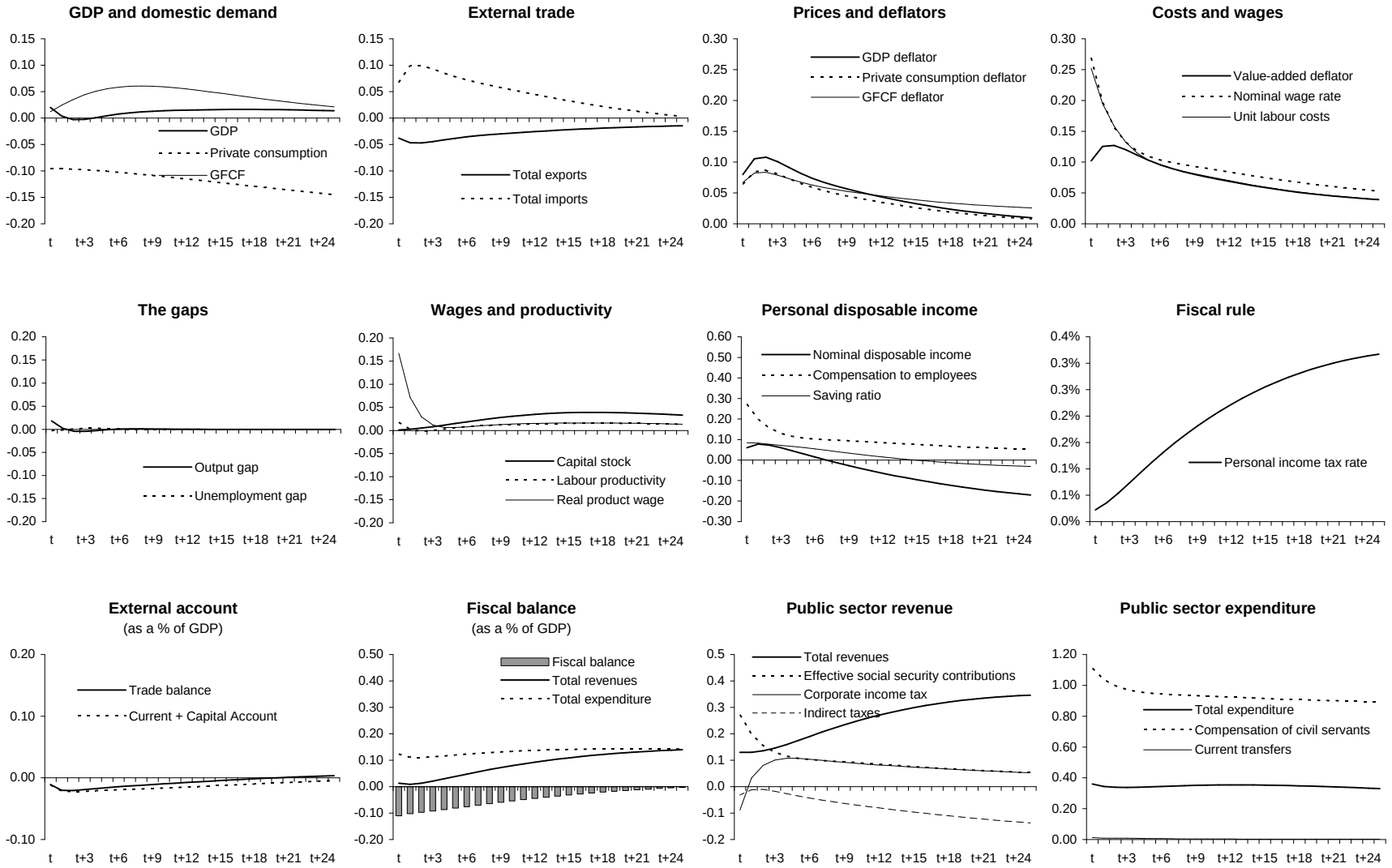

Figure 9. Permanent increase of 1% in the public sector nominal wage rate

6 Concluding remarks

The macroeconomic model presented in this paper is a simple structural model for a small open economy integrated in a monetary union subject to budgetary requirements. The model includes optimising behaviour of economic agents and is, in most cases, supported by explicit microfoundations, enabling the simulation of some external environment and fiscal policy shocks in a framework that is less prone to the Lucas critique than traditional macroeconometric models. In fact, in the context of this model, economic agents anticipate the most likely path of the variables of interest and maximise their objective functions taking this information into account. Thus, the reduced-form parameters of the behavioural equations reflect the impact of the shocks on the structural parameters of the model.

The main behavioural equations were derived from economic agents' constrained optimisation problems. However, the model still includes some ad-hoc parts and some exogenous variables that should be treated as endogenous. In particular, labour supply is fully exogenous, limiting the reliability of the simulations that are likely to influence the optimal labour/leisure time allocation by households. Additionally, the pricing scheme used in the model is open to significant improvements, particularly if indirect tax simulations are a major issue.

The model was calibrated for Portugal using different pieces of information, namely information describing the structure of the Portuguese economy,[29] the benchmark values used in similar macromodels and the shape of the impulse responses to the external environment simulations. Of course, an econometric estimation of the model would be highly desirable, but the traditional estimation techniques do not provide reliable estimates and most advanced estimation techniques are not still developed to enable the estimation of models with the size of the one presented here in an efficient way (e.g. the AINO model for the Finnish economy presented in Kilponen, Kontulainen, Rippati and Vilmunen (2004) and the Bank of England Quarterly Model presented in Harrison, Nikolov, Quinn, Ramsay, Scott and Thomas (2005) are fully calibrated).

Regarding the simulation exercises carried out using the model, it should be noted that all the shocks are permanent in order to evaluate the ability of the model to simulate transitions from one steady state to another. The speed of convergence and the long-run impacts of the shocks seem quite plausible and the model exhibits long-run neutrality, converging to the new steady state in a reasonable time span. However, some unsatisfactory features arise due to the jumpy behaviour of private consumption. In particular, this has led to enormous short-run impacts on economic activity of all the shocks that are likely to affect this variable permanently; the opposite applies to all the shocks that do not affect it in the long run. Most probably, the introduction of habit persistence in household preferences[30] and learning in the households' expectations formation mechanism instead

[29] This refers mainly to the information provided in the input-output tables.

[30] It should however be noted that habit persistence does not find strong empirical support.

of perfect foresight,[31] could have led to more persistency in private consumption and in output, improving the reasonability of the impulse response functions of the simulations.

Finally, the model is open to several improvements. Besides those mentioned above, the supply-side of the model is open to extensions, since the classical Cobb-Douglas production function is probably too restrictive, as it implies a rigid structure of factor demands. An interesting extension would be to consider a CES production function, enabling an elasticity of substitution between labour and capital different from unity. Furthermore, the proper simulation of an oil price shock as a supply-side shock implies a richer supply-side specification and, in particular, a production function properly combining imported oil, as an intermediate imported good, with labour input and the capital stock.[32]

Several studies aimed at providing empirical evidence of habit persistence using macro and micro data have not been very successful. Furthermore, many others that test for habit persistency reject this assumption, for instance, in Kuismanen and Pistaferri (2005) evidence raised using micro data suggests that durability instead of habit persistence is found in the data set.

[31] An interesting approach on learning mechanisms and rational expectations can be found in Evans and Honkapohja (2001)

[32] See, for instance, Bruno and Sachs (1985) and Backus and Crucini (2000)

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Annexes

A The variables of the model

Table A.1. The variables of the model

Name	Description	Name	Description
ASS	Asset wealth	PCD	Private consumption deflator
BGS	Balance of goods and services	PCR	Real private consumption (1995 prices)
BIN	Income balance	$PMAN$	Export prices of manufactured goods (local currency)
BKA	Capital transfers from abroad	PMN	Imports deflator excluding energy
BOP	Current account + new capital account	PRD	Labour productivity
CAC	Current account	PYN	Households disposable income
CGR	Public consumption (1995 prices)	PYR	Households real disposable income
DTO	Other tranfers to households	RCU	Goverment current revenue
DTT	Tranfers to households	ρ	Real discount factor
EER	Effective exchange rate	ρ^n	Nominal discount factor
EXD	External demand	RKA	Goverment capital revenues
GCU	Government current expenditure	ROS	Other government revenues
GIC	Government intermediate consumption	r	Short-term real interest rate
GIN	Goverment interest payments	RTC	Corporate income tax revenue
GKA	Government capital expenditure	RTD	Direct taxes revenue
GKO	Government capital expenditure - other	RTH	Personal income tax revenue
GPD	Public debt	RTI	Indirect tax revenue
GTC	Government current transfers	RTN	Government total revenues
GTH	Government transfers to households	SAV	Households saving rate
GTH^{PEN}	Government transf. households - pensions	SGL	Global balance
GTH^{URX}	Government transf. households - unemployment benefits	SPR	Primary balance
GTN	Govermnent expenditure	SSC	Total social security contributions
GTO	Govermnent transfers - other	SSE	Effective social security contributions
GTP	Govermnent primary expenditure	TFT	Total factor productivity
$HICP$	HICP overall	TRC	Current transfers from abroad
$HICPEN$	HICP energy	ULC	Unit labour costs
$HICPX$	HICP excluding energy	URT	NAIRU
ipd	Public debt interest rate	URX	Unemployment rate
IGN	GFCF of the public sector	USD	Dollar-euro exchange rate
IGR	GFCF of the public sector (1995 prices)	WGD	Compensation of civil servants deflator
ilt	Long-term interest rate	WGN	Compensation of civil servants
IND	GFCF deflator	WGR	Compensation of civil servants (1995 prices)
π	Inflation rate	WRN	Nominal wage rate
INR	Real GFCF (1995 prices)	WRN^G	Nominal wage rate - public sector
i	Short-term interest rate	WRN^P	Nominal wage rate - private sector
KSR	Capital stock	WRR	Real consumption wage rate
LBF	Labour force	WRY	Real product wage rate
LSR	Real inventories (1995 prices)	WTN	Compensation to employees
LTG	Public sector employment	XTD	Exports deflator
LTP	Private sector employment	XTF	Nominal exports (FOB)
LTT	Employment	XTR	Real exports (1995 prices)
MED	Energy imports deflator	YED	GDP deflator
MND	Non-energy imports deflator	YEN	Nominal GDP
MTD	Imports deflator	YER	Real GDP (1995 prices)
MTF	Nominal imports (FOB)	YFD	Value-added deflator
MTR	Real imports (1995 prices)	YFN	Nominal value-added
NFA	Net foreign assets	YF^{tax}	Net tax rate on production
OGR	Other government consumption (1995 prices)	$YSUB$	Subsidies on productions
OIL	Oil prices in USD/bbl	$YTAX$	Taxes on production
OPY	Other personal income	YET	Potential output
PCN	Nominal private consumption	Γ^h	Personal income tax rate

B The equations used in the model

The structural model equations are listed below. Some conventions are used here: (i) exogenous variables are identified by a bar over the variable name; (ii) the fiscal rule target levels are identified by the superscript *tar*; and (iii) expected values of variables are identified by the superscript *e*.

B.1 Main behavioural equations

Time-varying discount factors

$$\rho_t = \frac{1}{(1+\chi)\cdot(1+r_t)} \tag{B.1}$$

$$\rho_t^n = \frac{1}{(1+\chi)\cdot(1+i_t)} \tag{B.2}$$

Employment

$$LTT_t = \frac{1}{1+\varrho+\rho} LTT_{t-1} + \frac{\rho}{1+\varrho+\rho} E_t LTT_{t+1} + \frac{\varrho}{1+\varrho+\rho}\left(\frac{YER_t}{TFT_t \cdot KSR_t^{\alpha}}\right)^{\frac{1}{1-\alpha}} \tag{B.3}$$

Potential output and total factor productivity

$$YET_t^* = TFT_t \cdot KSR_t^{\alpha} \cdot LTT_t^{1-\alpha} \tag{B.4}$$

$$TFT_t = TFT_{t-1} \cdot [1 + g \cdot (1-\alpha)] \cdot \left(1 + \sigma_t^{TFT}\right) \tag{B.5}$$

Capital stock and gross fixed capital formation

$$\begin{aligned} &\rho_t^2 b \Delta \log KSR_{t+2} - \left(\rho_t^2 b^2 + \rho_t (1+b)\right) \Delta \log KSR_{t+1} \\ &+ \left(\rho_t b (1+b) + 1\right) \Delta \log KSR_t - b \Delta \log KSR_{t-1} \\ &= \frac{1}{a}\left[\frac{YFD_t}{IND_t} \cdot \left(\alpha \cdot \frac{YER_t}{KSR_t}\right) - \frac{(1+r_t)(1+\chi)(1+\delta)-1}{(1+r_t)(1+\chi)(1-\Gamma^c)}\right] \end{aligned} \tag{B.6}$$

$$INR_t = KSR_t - (1-\delta) \cdot KSR_{t-1} \tag{B.7}$$

Compensation per employee

$$WRN_t = \frac{1-q}{1+(1-q)(1-q)\tilde{\rho}} WRN_{t-1} + \frac{(1-q)\tilde{\rho}}{1+(1-q)(1-q)\tilde{\rho}} E_t WRN_{t+1} + \frac{q(1-(1-q)\tilde{\rho})}{1+(1-q)(1-q)\tilde{\rho}} \cdot \left[\frac{YFN \cdot (1-\alpha)}{LTT_t} \cdot (1-\eta\,(URX_t - URX_t^*)) \right] \quad \text{(B.8)}$$

Private consumption

$$PCR_t = \left(\frac{1-p}{1-(1-p)\cdot(1-\theta\,(1-p))} \right) \cdot \frac{E_t PCR_{t+1}}{(1+r_t)\cdot(1+\chi)} + \left(\frac{p\,(1-\theta\,(1-p))}{1-(1-p)\cdot(1-\theta\,(1-p))} \right) \cdot \left(\frac{ASS_{t-1}}{PCD_t} + \frac{PYN_t}{PCD_t} \right) \quad \text{(B.9)}$$

Asset wealth

$$ASS_t = \frac{1}{(1+i_t)(1+\chi)} \cdot E_t(ASS_{t+1} - GPD_{t+1} - NFA_{t+1}) + (YFN_t - WTN_t - \delta * KSR_{t-1} * IND_t - RTC_t) + GPD_t + NFA_t \quad \text{(B.10)}$$

Inventories

$$LSR_t = k \cdot YET_t - \frac{1}{\varpi}\,(YER_t - YET_t) - \frac{\rho}{\varpi} E_t\,(YER_{t+1} - YET_{t+1}) \quad \text{(B.11)}$$

Exports

$$XTR_t = \left(\frac{MTD_t}{MND_t} \right)^{\varepsilon} \cdot EXD_t \quad \text{(B.12)}$$

Imports

$$MTR_t = (1-\gamma_1) \cdot \left(\frac{YED_t}{MTD_t} \right) \cdot PCR_t + (1-\gamma_2) \cdot \left(\frac{YED_t}{MTD_t} \right) \cdot CGR_t + (1-\gamma_3) \cdot \left(\frac{YED_t}{MTD_t} \right) \cdot INR_t + (1-\gamma_4) \cdot \left(\frac{YED_t}{MTD_t} \right) \cdot \Delta LSR_t + (1-\gamma_5) \cdot \left(\frac{YED_t}{MTD_t} \right) \cdot XTR_t \quad \text{(B.13)}$$

Value-added deflator

$$YFD_t = \frac{1}{1+\mu+\tilde{\rho}} YFD_{t-1} + \frac{\tilde{\rho}}{1+\mu+\tilde{\rho}} E_t YFD_{t+1} + \frac{\mu}{1+\mu+\tilde{\rho}} \frac{WRN_t \cdot LTT_t}{(1-\alpha) YER_t} \quad \text{(B.14)}$$

Expenditure deflators

$$PCD_t = \Gamma_1 \cdot (YED_t)^{\gamma_1} \cdot (MTD_t)^{1-\gamma_1} \quad \text{(B.15)}$$
$$IND_t = \Gamma_3 \cdot (YED_t)^{\gamma_3} \cdot (MTD_t)^{1-\gamma_3} \quad \text{(B.16)}$$
$$XTD_t = \Gamma_5 \cdot (YED_t)^{\gamma_5} \cdot (MTD_t)^{1-\gamma_5} \quad \text{(B.17)}$$
$$MTD_t = MND_t^{\omega} \cdot MED_t^{1-\omega} \quad \text{(B.18)}$$
$$MND_t = \Omega_1 \cdot PMAN_t \cdot EER_t \quad \text{(B.19)}$$
$$MED_t = \Omega_2 \cdot OIL_t / USD_t \quad \text{(B.20)}$$

B.2 The block of expenditure

GDP at market prices and factor costs

$$YEN_t = YFN_t + YTAX_t - YSUB_t \quad \text{(B.21)}$$
$$YFN_t = YER_t \cdot YFD_t \quad \text{(B.22)}$$
$$YED_t = YEN_t / YER_t \quad \text{(B.23)}$$
$$YTAX_t = YTAX_{t-1} \cdot RTI_t / RTI_{t-1} \quad \text{(B.24)}$$
$$YSUB_t = YSUB_{t-1} \cdot GTO_t / GTOt - 1 \quad \text{(B.25)}$$
$$YF_t^{tax} = YED_t / YFD_t - 1 \quad \text{(B.26)}$$

Other expenditure variables

$$PCN_t = PCR_t \cdot PCD_t \quad \text{(B.27)}$$
$$CGR_t = WGR_t + OGR_t \quad \text{(B.28)}$$

B.3 Prices, wages and production costs

HICP equations

$$HICP_t = HICP_{t-1} \cdot (PCD_t / PCD_{t-1}) \quad \text{(B.29)}$$
$$HICPX_t = HICPX_{t-1} \cdot \left(\frac{HICP_t / HICP_{t-1}}{(HICPEN_t / HICPEN_{t-1})^{w^{NRG}}} \right)^{\frac{1}{1-w^{NRG}}} \quad \text{(B.30)}$$
$$HICPEN_t = HICPEN_{t-1} \cdot (MED_t / MED_{t-1})^{w^{MED}} \cdot (YED_t / YED_{t-1})^{1-w^{MED}} \quad \text{(B.31)}$$

Inflation and real interest rate

$$\pi_t = (PCD_t/PCD_{t-1}) - 1 \quad \text{(B.32)}$$
$$r_t = \frac{1+i_t}{1+\pi_t} - 1 \quad \text{(B.33)}$$

Wages and unit labour costs

$$WRR_t = WRN_t/PCD_t \quad \text{(B.34)}$$
$$WRY_t = WRN_t/YFD_t \quad \text{(B.35)}$$
$$WRN^P_t = WRN^P_{t-1} \cdot (WRN_t/WRN_{t-1}) \quad \text{(B.36)}$$
$$WRN^G_t = WRN^G_{t-1} \cdot (WRN_t/WRN_{t-1}) \quad \text{(B.37)}$$
$$ULC_t = WTN_t/YER_t \quad \text{(B.38)}$$

B.4 Labour market

$$URX_t = (1 - LTT_t/LBF_t) \cdot 100 \quad \text{(B.39)}$$
$$PRD_t = YER_t/LTT_t \quad \text{(B.40)}$$
$$LTP_t = LTT_t - LTG_t \quad \text{(B.41)}$$

B.5 Private disposable income, its components and the saving rate

$$\begin{aligned} PYN_t = & YFN_t - RTC_t + DTT_t + (TRX_t + BIN_t + BKA_t) \\ & - RTH_t - SSC_t + GIN_t - \delta \cdot KSR_{t-1} \cdot IND_t \end{aligned} \quad \text{(B.42)}$$

$$WTN_t = WRN_t \cdot LTT_t \quad \text{(B.43)}$$
$$WGN_t = WRN^G_t \cdot LTG \quad \text{(B.44)}$$
$$WGR_t = WGN_t/WGD_t \quad \text{(B.45)}$$
$$WGD_t = WGD_{t-1} \cdot (1 + \pi_t) \quad \text{(B.46)}$$
$$DTT_t = GTH_t + DTO_t \quad \text{(B.47)}$$
$$DTO_t = DTO_{t-1} \cdot (YEN_t/YEN_{t-1}) \quad \text{(B.48)}$$
$$OPY_t = OPY_{t-1} \cdot (YEN_t/YEN_{t-1}) \quad \text{(B.49)}$$
$$SSC_t = SSC_{t-1} \cdot (SSE_t/SSE_{t-1}) \quad \text{(B.50)}$$
$$PYR_t = PYN_t/PCD_t \quad \text{(B.51)}$$
$$SAV_t = (1 - PCN_t/PYN_t) * 100 \quad \text{(B.52)}$$

B.6 The public sector account

B.6.1 The revenue account

Total, current and capital revenue definitions

$$RTN_t = RCU_t + \overline{RKA_t} \quad \text{(B.53)}$$
$$RCU_t = RTD_t + RTI_t + SSE_t + ROS_t \quad \text{(B.54)}$$

Direct taxes on households and corporate income tax

$$RTD_t = RTH_t + RTC_t \quad \text{(B.55)}$$
$$RTH_t = \Gamma^h \cdot WTN_t \quad \text{(B.56)}$$
$$RTC_t = \Gamma^c \cdot YEN_t \quad \text{(B.57)}$$

Indirect taxes

$$RTI_t = \Gamma^i \cdot YEN_t \quad \text{(B.58)}$$

Social security contributions

$$SSE_t = \Gamma^s \cdot WTN_t \cdot \quad \text{(B.59)}$$

Other current revenue

$$ROS_t = ROS_{t-1} \cdot \frac{YEN_t}{YEN_{t-1}} \quad \text{(B.60)}$$

B.6.2 The expenditure account

Total, current and capital expenditure definitions

$$GTN_t = GCU_t + GKA_t \quad \text{(B.61)}$$
$$GCU_t = WTN_t^G + \overline{GIC_t} + GTC_t + GIN_t \quad \text{(B.62)}$$
$$GKA_t = \overline{IGN_t} + \overline{GKO_t} \quad \text{(B.63)}$$

Current transfers, social payments and other transfers

$$GTC_t = GTH_t + \overline{GTO_t} \tag{B.64}$$
$$GTH_t = GTH_t^{URX} + GTH_t^{PEN} \tag{B.65}$$
$$GTH_t^{PEN} = GTH_{t-1}^{PEN} \cdot \frac{WRN_t^P}{WRN_{t-1}^P} \tag{B.66}$$

Unemployment benefits

$$GTH_t^{URX} = GTH_{t-1}^{URX} \cdot \left(\frac{urx_t \cdot \overline{LBF_t}}{urx_{t-1} \cdot \overline{LBF_{t-1}}} \right) \cdot \frac{WRN_t^P}{WRN_{t-1}^P} \tag{B.67}$$

Public debt interest payments and interest rate

$$GIN_t = GPD_{t-1} \cdot ipd_t \tag{B.68}$$
$$ipd_t = 0.5 \cdot ipd_{t-1} + 0.5 \cdot ilt_t \tag{B.69}$$

B.6.3 The primary and the global balance and public debt

Primary balance

$$SPR_t = RTN_t - (GTN_t - GIN_t) \tag{B.70}$$

Global balance

$$SGL_t = RTN_t - GTN_t \tag{B.71}$$

Public debt

$$GPD_t = GPD_{t-1} - SGL_t \tag{B.72}$$

B.6.4 The fiscal rule

Fiscal rule on taxes over households income

$$\Gamma_t^h = \Gamma_{t-1}^h + \theta_1 \left(\frac{GPD_{t-1}}{YEN_{t-1}} - \left(\frac{GPD}{YEN} \right)^{tar} \right) - \theta_2 \left(\frac{SGL_{t-1}}{YEN_{t-1}} - \left(\frac{SGL}{YEN} \right)^{tar} \right) \tag{B.73}$$

B.7 The balance of payments and net foreign assets

Trade balance on goods and services, nominal exports and imports

$$BGS_t = XTF_t - MTF_t \tag{B.74}$$

$$XTF_t = XTF_{t-1} \cdot \frac{XTR_t}{XTR_{t-1}} \cdot \frac{PMN_t}{PMN_{t-1}} \tag{B.75}$$

$$MTF_t = MTF_{t-1} \cdot \left(\frac{MTR_t}{MTR_{t-1}} \cdot \frac{PMN_t}{PMN_{t-1}} \right)^{1-\omega} \cdot \left(\frac{OIL_t}{OIL_{t-1}} \cdot \frac{USD_{t-1}}{USD_t} \right)^{\omega} \tag{B.76}$$

Income balance and income balance interest rate

$$BIN_t = \left(BIN_{t-1} \cdot \frac{ilt_t}{ilt_{t-1}} + BOP \cdot ilt_t \right) \tag{B.77}$$

Current and capital transfers from abroad

$$TRC_t = TRC_{t-1} \cdot \frac{YEN_t}{YEN_{t-1}} \tag{B.78}$$

$$BKA_t = BKA_{t-1} \cdot \frac{RKA_t}{RKA_{t-1}} \tag{B.79}$$

Current account + New capital account

$$BOP_t = BGS_t + BIN_t + TRC_t + BKA_t \tag{B.80}$$