How Effective is Government Spending in a Small Open Economy with Distortionary Taxes

Carlos J. García and Jorge E. Restrepo*

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Abstract

We build a general equilibrium model of a small open economy, which includes rule-of-thumb consumers, and staggeredd prices and wages, as well as distortionary taxes. The analysis of government spending based on the responses to a government spending shock under three different rules and the sensitivity of several impact multipliers to alternative calibrations. The effect of the shock on consumption and GDP depends on the price elasticity of net exports; the share of rule-of-thumb consumers and domestic goods in the government basket; and finally, the fiscal rule in place. Indeed the response of consumption is more persistent with the rule that adjust spending to close the debt-financed deficit than with the other two rules.

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*Carlos García is professor at ILADES-Georgetown, Universidad Alberto Hurtado. Jorge E. Restrepo works for the Central Bank of Chile. We thank Riku Kinnunen for his comments, and William Baeza for his help with a code used in the sensibility analyses. Consuelo Edwards helped us with the edition. The authors are solely responsible for the opinions here expressed. E-mail addresses: jrestrepo@bcentral.cl, Carlos García: cgarcia@uahurtado.cl

1 Introduction

We build a general equilibrium model of a small open economy, which includes rule-of-thumb consumers, and staggered prices and wages as well as distortionary taxes. We concentrated on the analysis of a government spending shock under three different rule-based fiscal regimes, with and without distortionary taxation[1]. First, there is a fiscal rule with the budget being balanced at all times. In a second rule the tax rate is an endogenous variable and responds to both government spending and the level of public debt, similar to the rule used in Galí, López-Salido and Vallés (2005). A third fiscal rule mimics, broadly speaking, the one in place in Chile since 2001[2]. With this rule, spending slowly reacts to any deviation from fiscal balance, leading to the fiscal deficit being countercyclical[3].

The analysis of the interaction of the variables in the model is based on their responses to the shocks and also on the sensitivity of several impact multipliers to alternative calibrations and/or to changes in the policy parameters. The results confirm that in a small open economy, the effects of government spending on consumption and GDP depend on the price elasticity of net exports (Marshall-Lerner condition), because of the currency appreciation it usually generates. If there is a strong negative effect on net exports, public spending will not be much of a stimulus to the economy. In this case, the results will be consistent with the traditional Mundell-Fleming prescription: in an open economy with flexible exchange rate, government expenditures are generally less efficient as a tool to expand GDP (Blanchard, 2001). It is even more the case when distortionary taxes are in place. In addition, the impact of the shock on consumption and GDP grows with the share of rule-of-thumb consumers and domestic goods in the government basket.

The presence of distortionary taxes plays a central role when explaining how

[1]Recent empirical work on the effects of government spending include Ramey and Shapiro (1998), Fatás and Mihov (2001), Blanchard and Perotti (2002), Mountford and Ulhig (2002), Perotti (2002). For emerging economies see Restrepo and Rincón (2005) also Cerda, Lagos and González (2004).

[2]The Chilean fiscal authority established that spending will be adjusted to meet the goal of 1% structural surplus. "Structural" refers here to trend revenues, which are associated with trend GDP growth and the long-run price of copper. If GDP is growing less than its trend, government spending will be larger than its revenues, resulting in a countercyclical fiscal deficit. Thus, spending will grow with trend GDP, given that it gradually reacts to structural revenues and/or to any deviation from the 1% structural surplus. The target of a 1% structural surplus was set to cover secular deficit of the Central Bank and future pension liabilities.

[3]Since this is a business cycle model, our steady-state fiscal balance corresponds to the structural one. Without loss of generality, instead of using a 1% surplus in steady state, we work in the model with a balanced steady-state (structural) fiscal budget.

the effects of an initially debt-financed government spending shock differs under the three alternative fiscal regimes. In other words, it is not innocuous how a fiscal deficit, initially financed with debt and caused by a spending shock, is closed later on. For instance, the positive response of consumption is more persistent with the rule that adjust spending than with the rule that increases tax rates to close the debt-financed deficit. By raising taxes, the latter rule quickly offsets the initial wealth effect of rule-of-thumb households. In addition, the more aggressive is the central bank fighting inflation, the smaller is the impact of the government spending shock on consumption and the more negative is the impact on investment.

As conclusion, our sensibility analysis shows that the most important factors influencing the effect of government spending on consumption, investment, the current account, and GDP are: the presence of rule-of-thumb consumers, the price elasticity of exports and imports (Marshall-Lerner conditions), the share of domestic goods in government consumption, the presence of distortionary taxes, and the policy parameters in the fiscal and monetary rules.

This article is organized as follows. We present the model in section 2. In section 3, we discuss the calibration of the parameters and analyze the dynamic effects of a fiscal shock. Finally, in section 4, we summarize the results and conclude.

2 Model

The small open economy is similar to the one presented in many recent **New-Keynesian optimizing models** with sticky prices and wages, where aggregate demand shocks affect output (Rotemberg and Woodford,1992, Clarida, Galí and Gertler,1999). In addition, we follow Galí et al. (2005), and include two types of households: optimizing and rule-of-thumb consumers. Moreover, we introduce distortionary taxation. There is also a continuum of perfectly monopolistic firms. Finally, there are monetary (central bank) and fiscal authorities. Fiscal policy is rule based and three alternative fiscal regimes are compared.

2.1 Household

There is a continuum of infinitely lived households indexed by $i \in [0, 1]$. A fraction λ of households consume their current labor income, do not save, and cannot smooth their consumption because they are credit restricted (rule of thumb consumers). Another fraction $(1-\lambda)$ save, have access to capital markets, and are able to smooth consumption. Therefore, their intertemporal allocation between consumption and savings is optimal (Ricardian or optimizing consumers).

2.1.1 Ricardian households

We assume that a representative Ricardian household maximizes the expected, E_o, present value of an infinite stream of utility by choosing consumption, C_t^o, hours of work, N_t^o, and government bonds, B_t^o:

$$E_o \sum \beta^t U(C_t^o(i), N_t^o(i)) \tag{1}$$

where $\beta \in (0,1)$ is the discount factor, and the utility function is $U(C_t^o(i), N_t^o(i))$. The household is subject to the budget constraint in nominal terms:

$$\begin{aligned}(1+\phi_t) P_t C_t^o(i) &= (1-\tau_t) W_t N_t^o(i) + (1-\tau_t) D_t^o(i) \\ &\quad - R_t^{-1} B_{t+1}^o(i) - S_t \left(\Phi\left(\frac{S_t B_t^*}{P_t Y_t}\right) R_t^* \right)^{-1} B_{t+1}^{o*}(i) \\ &\quad + B_t^o(i) + S_t B_t^{o*}(i).\end{aligned} \tag{2}$$

Where $C_t^o(i)$ is consumption, $D_t^o(i)$ are dividends from ownership of firms, $\Phi\left(\frac{S_t B_t^*}{P_t Y_t}\right)$ represents the country risk premium, S_t is the nominal exchange rate, $B_t^*(i)$ is private net foreign assets, W_t nominal wage rate, $N_t^o(i)$ hours, $B_t^o(i)$ government debt held by households and ϕ_t and τ_t are the rates of the consumption and income taxes, respectively. We only include income tax at the consumer level (stockholder), considering no tax on firms' not distributed (invested) profits.

Thus, in this economy, the consumption tax could be assimilated to a value added tax (VAT), which is commonly transferred by firms to the final consumer. Therefore, it affects (distorts) consumption of both types of households. In the case of Ricardian households, its change enters the Euler equation affecting intertemporal decisions. On the other hand, it reduces disposable income and consumption of all households. In addition, both types of taxes affect labor supply distorting production (see appendix). On the contrary, taxes do not affect the relative price of investment or distort it[4].

[4]Based on Bustos, Engel and Galetovic (2004), we implicitly assume that depreciation allowances and interest payments are roughly equivalent to the cost of investment. We also assume that firms do not internalize taxes paid by their stockholders. Those authors find negative marginal effective corporate tax rates for large corporations in Chile and also cite Jorgenson and Landau (1993), who find negative effective tax rates on capital in France and Italy in 1990.

The first-order condition for consumption is:

$$C_t^o(i) = \beta E_t\left(C_{t+1}^o(i)\frac{1}{R_t}\left(\frac{P_t}{P_{t+1}}\right)\left(\frac{1+\phi_{t+1}}{1+\phi_t}\right)\right) \tag{3}$$

Following Galí et al. (2005), we have not listed the first order condition for labor supply, because we have assumed some power market for household to determine wages.

The utility takes the form:

$$U(C,L) = \frac{C^{1-\sigma}}{1-\sigma} - \frac{N^{1+\varphi}}{1+\varphi} \tag{4}$$

where $(1/\sigma)$ is the intertemporal elasticity of substitution in consumption and φ is the elasticity of marginal disutility with respect to labor supply.

2.1.2 Rule-of-thumb households

Rule-of-thumb households do not save or borrow. Therefore, they always spend their current labor income (Jaffe and Stiglitz, 1990; Mankiw, 2000). Their utility is:

$$U(C_t^r(i), N_t^r(i)) \tag{5}$$

subject to:

$$(1+\phi_t)\,P_t C_t^r(i) = (1-\tau_t)\,W_t N_t^r(i) \tag{6}$$

Thus, they consume the wages they receive.

2.1.3 The wage schedule

Following Erceg, Henderson and Levin (2000), we suppose that households act as price-setters in the labor market[5]. There is a representative labor aggregator, and wages are staggered à la Calvo (1983). Therefore, wages can only be optimally changed after some random "wage-change signal" is received. A continuum of monopolistically competitive households is assumed to exist, and each one of them supplies a differentiated labor service to the intermediate-goods-producing sector. The representative labor aggregator combines, with a constant returns technology,

[5] Another alternative consists of modeling the labor market as in Galí et al. (2005), where real wages are determined with a general function, H, which is increasing in both consumption and employment: $\frac{W_t}{P_t} = H(C_t, N_t, \phi_t, \tau_t)$.

household labor hours in the same amount firms demand them. The aggregate labor index N_t has the CES or Dixit-Stiglitz form:

$$N_t = \left[\int_0^1 N_t(i)^{\frac{1}{1+\theta_w}} di \right]^{1+\theta_w} \tag{7}$$

where $N_t(i)$ is the quantity of labor provided by each household.

The representative labor aggregator takes each household's wage rate $W_t(i)$ as given, and minimizes the cost of producing a given amount of the aggregate labor index. Then, units of labor index are sold at their unit cost W_t (with no profit) to the production sector :

$$W_t = \left[\int_0^1 W_t(i)^{-\frac{1}{\theta_w}} di \right]^{-\theta_w} \tag{8}$$

Households set their nominal wages that maximize their intertemporal objective function (1), subject to the intertemporal budget constraint (2), and to the total demand for its labor services, which is given by:

$$N_t(i) = \left[\frac{W_t(i)}{W_t} \right]^{-\frac{1+\theta_w}{\theta_w}} N_t \tag{9}$$

Rule-of-thumb households set their wages equal to the average wage of optimizing households.

2.1.4 Demand for consumption goods

Overall, consumption is a CES aggregate of domestic and imported goods.

$$C_t = \left((1-\alpha_c) \left(C_t^D \right)^{\frac{\eta_c - 1}{\eta_c}} + \alpha_c \left(C_t^F \right)^{\frac{\eta_c - 1}{\eta_c}} \right)^{\frac{\eta_c}{\eta_c - 1}} \tag{10}$$

The demand for each bundle of differentiated domestic and imported goods, derived from expenditure minimization, is given by:

$$C_t^D = (1-\alpha_c) \left(\frac{P_t^D}{P_t} \right)^{-\eta_c} C_t \tag{11}$$

$$C_t^F = \alpha_c \left(\frac{P_t^F}{P_t} \right)^{-\eta_c} C_t \tag{12}$$

The aggregate consumer price index (CPI) is defined as:

$$P_t = \left((1-\alpha_c) \left(P_t^D \right)^{1-\eta_c} + \alpha_c \left(P_t^F \right)^{1-\eta_c} \right)^{\frac{1}{1-\eta_c}} \tag{13}$$

Each type of good is a composite (or weighted average) of either domestic or imported differentiated goods, which also consists of a Dixit-Stiglitz index:

$$C_t^K = \left(\int_0^1 C_t^K(j)^{\frac{\varepsilon_K - 1}{\varepsilon_K}} dj \right)^{\frac{\varepsilon_K}{\varepsilon_K - 1}} \tag{14}$$

$$C_t^K(j) = \left(\frac{P_t^K(j)}{P_t^K} \right)^{-\varepsilon_K} C_t^K \tag{15}$$

with the respective price index:

$$P_t^K = \left(\int_0^1 P_t^K(j)^{1-\varepsilon_K} dj \right)^{\frac{1}{1-\varepsilon_K}} \tag{16}$$

for $K = D, F$.

2.2 Domestic intermediate-goods firms

There is a continuum of monopolistically competitive firms, indexed by $j \in [0,1]$, producing differentiated intermediate goods.

2.2.1 Cost minimization

The CES production function of the representative intermediate-good firm, indexed by j, combines capital, K_t and labor, N_t to produce $Y_t(j)$, and is given by

$$Y_t^D(j) = A_t \left[\alpha K_t(j)_t^{\frac{\sigma_s - 1}{\sigma_s}} + (1-\alpha) N_t^{\frac{\sigma_s - 1}{\sigma_s}}(j) \right]^{\frac{\sigma_s}{\sigma_s - 1}} \tag{17}$$

where A_t and σ_s are both ≥ 0, and correspond to the technology parameter and the elasticity of substitution between capital and labor, respectively.

Firms minimize costs taking the rental price of capital R_t^k and the wage W_t as given, subject to the production function (technology). The first-order conditions yield the relative factor demands,

$$\frac{R_t^k}{W_t} = \left(\frac{\alpha}{1-\alpha} \right) \left(\frac{N_t(j)}{K_t(j)} \right)^{\frac{1}{\sigma_s}} \tag{18}$$

and the marginal cost, given by:

$$MC^{D} = \frac{1}{A_t}\left[\alpha^{\sigma_s}\left(R_t^k\right)^{1-\sigma_s} + (1-\alpha)^{\sigma_s}\left(W_t\right)^{1-\sigma_s}\right]^{\frac{1}{1-\sigma_s}}. \tag{19}$$

2.2.2 Price setting

Following Calvo (1983), when firm j receives a signal to optimally set a new price, it chooses the price that maximizes the discounted value of its profits, conditional on that price being effective:

$$\max \sum_{k=0}^{\infty} \theta_D^k E_t \left\{\Lambda_{t,t+k} Y_{t+k}^D(j)\left(P_t^{D*}(j) - MC_{t+k}^D\right)\right\} \tag{20}$$

subject to

$$Y_{t+k}^D(j) \leq \left(\frac{P_t^{D*}(j)}{P_t^D}\right)^{-\varepsilon_D} Y_{t+k}^D \tag{21}$$

where $P_t^{D*}(j)$ must satisfy the first-order condition

$$\sum_{k=0}^{\infty} \theta_D^k E_t \left\{\Lambda_{t,t+k} Y_{t+k}^D(j)\left(P_t^{D*}(j) - \frac{\varepsilon_D}{\varepsilon_D - 1} MC_{t+k}^D\right)\right\} = 0 \tag{22}$$

with the discount factor being

$$\Lambda_{t,t+k} = \beta^k \left(\frac{C_{t+k}^o}{C_t^o}\right)^{-\sigma}\left(\frac{P_t}{P_{t+1}}\right) \tag{23}$$

Then, under the assumed price-setting structure, firms that did not receive the signal cannot adjust their prices, while all those that are allowed to optimally reset their prices choose the same price P_t^*. Thus, the dynamics of the domestic price index P_t^D is finally described by the equation

$$P_t^D = \left[\theta_D\left(P_{t-1}^D\right)^{1-\varepsilon_D} + (1-\theta_D)\left(P_t^{D*}\right)^{1-\varepsilon_D}\right]^{\frac{1}{1-\varepsilon_D}}. \tag{24}$$

2.3 Intermediate-goods importing firms

The import sector buys a homogenous good produced abroad, and using a linear technology turns it into a differentiated import good for the home market. As in the domestic good sector, importing firms also receive a random signal to optimally set a new price when the exchange rate or the foreign price has changed (Smets and Wouters, 2002). Thus, there is no perfect pass-through and the dynamics of the import price index is also described by an equation similar to (24). However, the firms that are allowed to optimally reset their price, set it equal to the import price abroad in terms of domestic currency $S_t P_t^{F*}$ (law of one price).

$$P_t^F = \left[\theta_F \left(P_{t-1}^F\right)^{1-\varepsilon_F} + (1-\theta_F)\left(S_t P_t^{F*}\right)^{1-\varepsilon_F}\right]^{\frac{1}{1-\varepsilon_F}} \tag{25}$$

2.4 Optimizing investment firms

The firms that produce homogenous capital goods rent them to the intermediate-goods firms. All of them are owned by Ricardian households.

2.4.1 Tobin's Q

Firms invest the amount that solves the following problem:

$$V^t(K_t^o) = R_t^k K_t^o - P_t^I I_t^o + E_t\left(V^{t+1}\left(K_{t+1}^o\right)\right) \tag{26}$$

subject to capital accumulation

$$K_{t+1}^o = (1-\delta) K_t^o + \phi\left(\frac{I_t^o}{K_t^o}\right) K_t^o \tag{27}$$

The first order conditions for the investment firm are:

$$Q_t^o \phi'\left(\frac{I_t^o}{K_t^o}\right) - \frac{P_t^I}{P_t} = 0 \tag{28}$$

$$Q_t^o = E_t\left\{\frac{1}{R_t}\left(\frac{P_t}{P_{t+1}}\right)\left[\frac{R_{t+1}^k}{P_{t+1}} + Q_{t+1}^o\left((1-\delta) + \phi - \frac{I_{t+1}^o}{K_{t+1}^o}\phi'\right)\right]\right\} \tag{29}$$

The marginal cost of an additional unit of investment should be equal to the present value of the marginal increase in equity that it generates (Tobin's Q).

2.4.2 Demand for investment goods

Investment consists of a CES aggregate of domestic and imported goods

$$I_t = \left((1-\alpha_I)\left(I_t^D\right)^{\frac{\eta_I - 1}{\eta I}} + \alpha_I\left(I_t^F\right)^{\frac{\eta_I - 1}{\eta I}}\right)^{\frac{\eta_I}{\eta I - 1}} \tag{30}$$

The demand for domestic and imported goods derived from expenditure minimization is given by:

$$I_t^D = (1-\alpha_I)\left(\frac{P_t^D}{P_t^I}\right)^{-\eta_I} I_t \tag{31}$$

$$I_t^F = \alpha_I \left(\frac{P_t^F}{P_t^I}\right)^{-\eta_I} I_t \tag{32}$$

The aggregate price is defined as

$$P_t^I = \left((1-\alpha_c)\left(P_t^D\right)^{1-\eta_I} + \alpha_c\left(P_t^F\right)^{1-\eta_I}\right)^{\frac{1}{1-\eta_I}} \tag{33}$$

Each composite of investment goods is itself a bundle of differentiated goods. For $K = D, F$.

$$I_t^K = \left(\int_0^1 I_t^K(j)^{\frac{\varepsilon_K - 1}{\varepsilon_K}} dj\right)^{\frac{\varepsilon_K}{\varepsilon_K - 1}} \tag{34}$$

$$I_t^K(j) = \left(\frac{P_t^K(j)}{P_t^K}\right)^{-\varepsilon_K} I_t^K \tag{35}$$

2.4.3 Aggregation

Aggregate consumption corresponds to the weighted sum of consumption by Ricardian and rule of thumb households

$$C_t = \lambda C_t^r + (1-\lambda) C_t^o = \int_0^\lambda C_t^r(i)di + \int_\lambda^1 C_t^o(i)di \tag{36}$$

Given that only Ricardian households invest and accumulate capital, total investment is equal to $(1-\lambda)$ times the optimizing investment:

$$I_t = (1-\lambda)\left(I_t^o\right) \tag{37}$$

Similarly, the aggregate stock of capital is equal to

$$K_t = (1-\lambda)\left(K_t^o\right) \tag{38}$$

Hours worked are a weighted average of labor supplied by each type of consumer:

$$N_t = \lambda N_t^r + (1-\lambda) N_t^o \tag{39}$$

In equilibrium, each type of consumer works the same number of hours:

$$N_t = N_t^r = N_t^o \tag{40}$$

Financial assets are only held by optimizing households:

$$B_t = (1-\lambda)\left(B_t^o\right) \tag{41}$$

Foreign assets (or debt) includes fiscal $B_t^{G*}$and private assets B_t^{o*}:

$$B_t^* = B_t^{G*} + (1-\lambda)B_t^{o*} \tag{42}$$

2.5 Monetary policy

The central bank sets the nominal interest rate according to the following rule:

$$r_t = \overline{r} + \phi_\pi \pi + \phi_y y \tag{43}$$

with $\phi_\pi \geq 1$ and $\overline{r}$ being the neutral or steady state nominal interest rate. This rule is similar to the well known Taylor (1993) rule. In our baseline simulation, ϕ_y=0.

2.6 Fiscal policy

The government budget constraint is

$$\begin{aligned} P_t^G G_t &= \phi_t P_t C_t + \tau_t W_t N_t + (1-\lambda)\tau_t D_t^o \\ &\quad + R_t^{-1} B_{t+1} + S_t \left(\Phi\left(\frac{S_t B_t^*}{P_t Y_t}\right) R_t^* \right)^{-1} B_{t+1}^{G*} - B_t - S_t B_t^{G*} \end{aligned} \tag{44}$$

where income tax revenues can be expressed as:

$$\tau_t \left(P_t^D Y_t^D - P_t^I I_t + \left(P_t^F - S_t P_t^{F*}\right) Y_t^F\right). \tag{45}$$

Thus, revenues are net of investment and include profits of the import sector.

For simplicity, we assume that whenever the government issues debt it maintains a fixed proportion of domestic and external debt: $S_t B_t^{G*} = \upsilon_b B_t^G$

2.6.1 Fiscal Rules

We propose a general fiscal rule that may encompass a wide range of different cases. Letting $g_t = \frac{G_t - G}{Y}$, $t_t = \frac{T_t - T}{Y}$ and $b_t = \frac{\frac{B_t^o}{P_t} - \frac{B^o}{P}}{Y}$, the rule takes the following form:

$$\psi \phi_t P_t C_t + \omega \tau_t \left(P_t^D Y_t^D - P_t^I I_t + \left(P_t^F - S_t P_t^{F*} \right) Y_t^F \right) = \phi_b B_t + \phi_g P_t^G G_t \tag{46}$$

In order to have an interpretation of this rule, we choose some cases. if $\psi, \omega = 1$, the general rule becomes similar to the one proposed by Galí et al. (2005), where in order to return to equilibrium tax rates (in consumption tax instead of a lump-sum tax) adjust according to the levels of spending and public debt:

$$\phi_t P_t C_t + \tau_t \left[P_t^D Y_t^D - P_t^I I_t + \left(P_t^F - S_t P_t^{F*} \right) Y_t^F \right] = \phi_b B_t + \phi_g P_t^G G_t \tag{47}$$

If $\psi = \omega = \phi_g = 1$ and $\phi_b = 0$, we are dealing with a balanced budget, where taxes also adjust to maintain the budget balanced each period:

$$\phi_t P_t C_t + \tau_t \left[P_t^D Y_t^D - P_t^I I_t + \left(P_t^F - S_t P_t^{F*} \right) Y_t^F \right] = P_t^G G_t \tag{48}$$

We consider a third rule, where the government adjusts spending, instead of taxes, to go back to equilibrium, whenever facing a debt-financed fiscal deficit. In the meantime, the level of debt will grow up to the point where revenues and expenditures equilibrate again. This new level of debt will remain forever unless there is a shock that could take it to an even higher level or that increases revenues and allows the government to run transitory surpluses and reduce its outstanding debt. In other words, government debt follows a random walk[6]. In this case the coefficients would be $\psi = \omega = 0$ and $\phi_g = 1$, so the rule becomes

$$P_t^G G_t = \overline{IT} - \frac{i_t}{1 + i_t} B_t - \frac{i_t^*}{1 + i_t^*} S_t B_t^*, \tag{49}$$

Note that while the other rules include current tax revenue:

[6] The Chilean fiscal rule of structural overall surplus assures the financial solvency of the government in the long run. However, it could still be possible under this rule to accumulate substantial debt were the assumptions regarding potential GDP and the long-run copper price for several years misaligned. Indeed, if authorities' perception (or, in the case of Chile, the group of independent analysts) regarding these two unknown variables only adjust slowly when persistent changes have taken place, continuous deficit or surpluses are possible, given that they define the actual overall fiscal deficit or surplus allowed each period (see Restrepo, 2005).

$$IT_t = \phi_t P_t C_t + \tau_t \left[P_t^D Y_t^D - P_t^I I_t + \left(P_t^F - S_t P_t^{F*} \right) Y_t^F \right],$$

this rule considers steady-state (structural) taxes $\overline{IT}$. However, we cannot use such a rule in our model because it would not converge, given that public debt corresponds to a random walk. For that reason, we allow the debt to have some weight in the rule. In such a way, the government expenditure has to pay the interest of the debt and a little more $\left[\frac{i_t}{1+i_t} + \frac{i_t^*}{1+i_t^*}\upsilon_b\right] B_t +\ \mu_x B_t$. In other words, government spending should also react to the level of debt B, with elasticity $\mu_x = 0.001$, so debt will slowly converge back to the steady-state level.

$$P_t^G G_t = -\frac{\phi_b}{\phi_g} B_t \tag{50}$$

where $\phi_g = 1$ and $\phi_b = \left[\frac{i_t}{1+i_t} + \frac{i_t^*}{1+i_t^*}\upsilon_b + \mu_x\right]$. Therefore, ϕ_b is not constant in this rule. However, after linearizing we get that ϕ_b is constant and equal to $\left[\frac{r}{1+r}\upsilon_b + \mu_x\right]$, because in steady state not only the budget is balanced (but also $\overline{B}^g = 0$)[7].

Plugging the rule in the budget constraint, a necessary and sufficient condition for non-explosive debt dynamics is given by:

$$\left(1 - \frac{\phi_b}{1+\upsilon_b}\right) < \left(\frac{1}{1+r}\right), \psi = \omega = 1 \tag{51}$$

and

$$\left(1 - \frac{\phi_b}{\phi_g\left(1+\upsilon_b\right)}\right) < \left(\frac{1}{1+r}\right), \psi = \omega = 0. \tag{52}$$

2.6.2 Government demand for goods

Government spends on an aggregate bundle of domestic and imported goods.

$$G_t = \left((1-\alpha_G) \left(G_t^D\right)^{\frac{\eta_G - 1}{\eta_G}} + \alpha_G \left(G_t^F\right)^{\frac{\eta_G - 1}{\eta_G}} \right)^{\frac{\eta_G}{\eta_G - 1}}. \tag{53}$$

The demand for domestic and imported goods is derived from expenditure minimization and is given by:

$$G_t^D = (1-\alpha_G)\left(\frac{P_t^D}{P_t^G}\right)^{-\eta_G} G_t \tag{54}$$

[7] As it is well known, the linearization of the model involves a tradeoff: understanding and simulating the model is simpler but some of the action is lost.

$$G_t^F = \alpha_G \left(\frac{P_t^F}{P_t^G} \right)^{-\eta_G} G_t. \tag{55}$$

The government price index (price deflator) is defined as:

$$P_t^G = \left((1-\alpha_G) \left(P_t^D\right)^{1-\eta_G} + \alpha_G \left(P_t^F\right)^{1-\eta_G} \right)^{\frac{1}{1-\eta_G}} \tag{56}$$

and each type of good (domestic and imported) is itself a bundle of differentiated goods

$$G_t^K = \left(\int_0^1 G_t^K(j)^{\frac{\varepsilon_K - 1}{\varepsilon_K}} dj \right)^{\frac{\varepsilon_K}{\varepsilon_K - 1}} \tag{57}$$

$$G_t^K(j) = \left(\frac{P_t^K(j)}{P_t^K} \right)^{-\varepsilon_K} G_t^K \tag{58}$$

for $K = D, F$.

2.7 Market clearing conditions

The factor market-clearing conditions are given by

$$N_t = \int_0^1 N_t(j) dj \tag{59}$$

$$K_t = \int_0^1 K_t(j) dj \tag{60}$$

and for the domestic market, by

$$Y_t^D(j) = \left(\frac{P_t^D(j)}{P_t^D} \right)^{-\varepsilon_D} \left(C_t^D + I_t^D + G_t^D + X_t^D \right). \tag{61}$$

Therefore, the supply of domestic goods equals the sum of consumption, investment, government spending and exports:

$$Y_t^D = C_t^D + I_t^D + G_t^D + X_t^D. \tag{62}$$

The economy equilibrium is:

$$P_t C_t + P_t^G G_t + P_t^I I_t = P_t^D Y_t^D + P_t^F Y_t^F - S_t P_t^{*F} Y_t^F + S_t \left(\Phi \left(\frac{e_t B_t^*}{P_t Y_t} \right) R_t^* \right)^{-1} B_{t+1}^* - S_t B_t^*. \quad (63)$$

3 Calibration and Dynamics

The model is first linearized (see the appendix), then the system of stochastic difference equations is solved with Dynare (Juillard, 2003)[8].

3.1 Calibration

The most important parameter values in our baseline simulation are set to equal standard values found in the literature and summarized in table 1. For instance, the discount factor β, is set at 0.99. The risk aversion coefficient in the consumption function is 1. We follow Galí et al. (2005) setting the elasticity of substitution across intermediate goods ε=6, and the rate of depreciation δ is 0.02. On the other hand, the share of rule-of-thumb consumers amounts to 0.5. Finally, we impose a relationship between local and foreign government debt $\left(\frac{B^G}{S_t B^{G*}}\right)$ of 0.21 at all times.

The policy parameters include: the share of domestic goods in the government basket of consumption α_G=0.9, as well as the coefficients in the monetary rule with respect to inflation and the output gap ϕ_π=1.5, the original value used in Taylor (1993), and ϕ_y=0, given that in our baseline simulation the monetary rule only includes inflation. However, we report sensibility analysis which were run in order to check how different values of both parameters affect the impact of government spending shocks. Finally, other policy parameters are the ones included in one of the fiscal rules, where taxes react endogenously to fiscal deficits, ϕ_g=0.30 and public debt ϕ_b=0.12 similarly to the rule used in Galí et al. (2005)[9].

In steady state consumption is set at 62% of GDP, government spending is 20% and so are tax revenues, since the overall government budget is assumed to be balanced in steady state[10]. This is equivalent to assuming structural balance — instead of the structural surplus adopted in Chile. The ratio of investment to GDP

[8] The software is available at: http://www.cepremap.cnrs.fr/dynare

[9] The consumption tax rate is the one that changes in order to regain fiscal equilibrium here, while in Galí et al. (2005), the tax that reacts is lump-sum.

[10] Several parameters used to calibrate the steady state are taken from Restrepo and Soto (2004).

is 17%, exports are 34%, while imports are slightly less than that 33%, given that the trade surplus covers the steady state interest payments on a 50% of GDP level of foreign private debt (table2).

3.2 Effects of fiscal spending shocks

The effects of a government spending shock on our economy are shown in **figure 1**, that includes the response of a selected group of variables: GDP, consumption, investment, real interest rate, inflation, hours of work, real wage, real exchange rate, current account, fiscal deficit and nominal interest rate. Each small figure depicts the response of the respective variable under the three different fiscal regimes, namely endogenous tax, endogenous spending and permanently-balanced budget.

1. The contemporaneous response of consumption to a government spending shock is positive, except under the rule of an always-balanced budget. Thus, the rules are responsible for the differences in the responses of consumption, which are also reflected on significant differences in the responses of the current account, the real wage, the real exchange rate and obviously the fiscal deficit.

Indeed, the results show that:

i) after the shock, consumption drops with **the balanced-budget rule** because the positive wealth effect that benefits rule-of-thumb consumers is partly offset by higher taxes on their income and consumption. Besides, the distortion on consumption and the negative wealth effect on Ricardian consumers are both so large with this rule that they counteract the positive wealth effect received by rule-of-thumb consumers, causing a deep fall in consumption, even in the presence of a significant real appreciation. The consumption reduction is mirrored by the strong current account improvement. The large current account surplus causes a reduction in total foreign debt and the risk premium, which are associated with the strong exchange rate appreciation (the IS curve comes back). As a result, the composition of aggregate demand (GDP) changed.

ii) The spending hike has the largest positive impact on consumption with **the rule that adjust taxes** (consumption tax) after the shock. It happens because the negative wealth effect suffered by Ricardian households is more than compensated by the increase in income and consumption experienced by rule-of-thumb agents. However the positive effect does not last long and becomes negative after two quarters, similarly to what happens with the balanced-budget rule because taxes increase significantly in order to take the budget back to equilibrium. Hence, the initial wealth gain of rule-of-thumb consumers is quickly reversed. At this time the effect on optimizers is still negative.

iii) Under **the fiscal regime that adjusts spending** in order to gradually return to equilibrium, total consumption increases less than with the last rule but the positive effect is very persistent, lasting eight to nine quarters. This happens even though inflation and the interest rate have the highest and more persistent increase. Moreover, the increment in the wage bill of rule-of-thumb consumers is smaller here than with the other two rules, because real wages do not move up significantly. What is different here is that under the endogenous spending rule, tax distortions though not absent are smaller because tax rates do not move. Thus, the increase in tax revenues with this rule (figure **1**), is an endogenous result of the increase in GDP after the shock. On the other hand, the real exchange rate appreciates less than when either of the other two rules operate, because the appreciating pressure of fiscal spending is partially offset by the force towards depreciation coming from the larger and more persistent current account deficit, and level of foreign debt, which is also associated with a higher country risk premium.

2. The effect of government spending on consumption and GDP depends also on the reaction of the real exchange rate, exports, and imports after the shock. A standard statement regarding open economies with flexible exchange rate regimes is that fiscal policy is less effective expanding the economy, given that it has a negative effect on net exports[11]. To check this result in our model, we obtained the impact multipliers (after a government spending shock) as a function of the price elasticity of export demand, and as a function of the price elasticity of imports, which in our baseline simulation are both 1.0[12]. **Figure 2** shows that the impact of the shock on GDP, consumption, the current account, worked hours, the real wage and inflation decreases whenever the elasticity of exports grows. The transmission mechanism works through the real exchange rate. Indeed, a real appreciation takes place after the shock, which engineers a reduction in total net exports by making domestic goods more expensive or, the same, foreign goods cheaper. The more negative the reaction of net exports to the real currency appreciation, the less expansive the public spending shock and the smaller the impact multiplier. The effect of the shock, at impact, on hours (employment) falls along with its impact on aggregate

[11] In the IS-LM jargon, what happens is that the IS comes back after the expansion due to the subsequent reduction of the real exchange rate, lowering exports and aggregate demand.

[12] The effect of a depreciation (appreciation) depends on the elasticities of export and import demands. After a depreciation, the trade account will improve if the Marshall-Lerner conditions hold, as it happens in our case.

demand, particularly on consumption, investment and net exports.

Similarly, whenever we increase the price elasticity of imports, there is a reduction in the impact of the spending shock on GDP, consumption, investment, current account, real wage and hours, as can be seen in **figure 3**. At the same time, and pulling the appreciation of the real exchange rate is, at impact, smaller.

Therefore, there are two opposite forces pushing and pulling the real exchange rate. On one hand, government spending puts downward pressure on the real exchange rate. On the other, the resulting debt-financed fiscal and current account deficits increase the country risk premium and pushes the real exchange rate up. The latter is a smaller effect that only comes out in a general equilibrium framework and was typically missing in the Mundell-Fleming models. In **figure 4**, we illustrate this effect by showing the evolution of the impact multipliers when we change the debt elasticity of the country risk premium. The impact of the spending shock on the variables is very different for each rule. Nevertheless, one can state that the real exchange rate appreciation is smaller with the two rules that allow the surging of a debt-financed deficit after the shock, but the effect is more significant with the rule that has taxes reacting endogenously to the fiscal deficit and public debt.

3. Distortionary taxes play a significant role in the economy. The differences generated by the three rules partly come from the distortion on consumption and labor supply created by both taxes, as becomes clear from comparing figures **1** and **5**. Indeed, **figure 5** shows the responses of the variables to a government spending shock when taxes are lump sum instead of being distortionary, as is the case in figure **1**.

For instance, the effect of government spending on consumption is larger with lump-sum taxes than with distortionary ones. Indeed, if the economy has only lump-sum taxes, consumption reacts more after the shock resulting in higher responses of inflation and real interest rates jointly with a lower response of the current account balance. On the contrary, if distortionary taxes are in place, the change in the tax rate on consumption that follows the spending spike distorts negatively the level of consumption with two out of the three rules. In fact, the tax change that occurs after the shock impacts negatively rule-of-thumb consumers and appears in the Euler equation of optimizing consumers affecting their decisions (see linearized model in the appendix).

It is important to point out that when the fiscal rule is built in such a way that government spending, instead of taxes, reacts endogenously in order to gradually go back to the target of a balanced budget (equilibrium), the positive effect of the shock on consumption is much more persistent than with the other rules and so is the effect of the shock on inflation and the real interest rate, with a negative effect on investment.

In addition, the reaction of real wages varies significantly depending on whether taxes are lump sum or not. While real wages increase after the shock in the presence of distortionary taxes with all three rules, they fall when taxes are lump sum with the two fiscal regimes where taxes react endogenously. It happens mostly because in the first case inflation is lower and labor supply falls. Finally, the real exchange rate falls less with lump sum taxes because net exports are smaller. So debt is larger and the country risk premium is higher.[13]

3.3 Sensibility analysis

To understand better how our economy works and to check the robustness of some results, several sensibility exercises are carried out. The exercises allow us to pin down the interaction of aggregate demand variables with a set of parameters of the model, in order to see, after the same government spending shock, how the impact multipliers of a group of variables change depending on the share of rule of thumb consumers λ, the degree of wage rigidity θ_w, the composition of government expenditures α_G, as well as the size of the coefficients in the monetary (ϕ_π and ϕ_y), and fiscal (ϕ_b and ϕ_g) rules. The sensibility analysis shows that in several cases the impact multipliers change not only size but also sign.

3.3.1 Model parameters

Figure 6 shows how the impact of the shock on each of the selected variables changes when the share of rule-of-thumb consumers λ, grows from **0** to **0.5,** half of a percentage point (0.05) at a time. It is clear that the effect of the shock on consumption, starting from being negative, grows with the share of rule-of-thumb consumers. The negative impact the shock has on the wealth of Ricardian (forward-looking) consumers is more than offset by the positive wealth effect received by rule of thumbers, who spend all their income. This result is in line with the findings of Galí et al. (2005) for a closed economy. The impact of the shock on GDP, inflation, and real interest rates also grows with the presence of credit-restricted consumers.

[13] As a way of checking the functioning of the model we also introduced a monetary shock and a shock to the price of exports. The responses are consistent with economic intuition in all cases. However, we do not report them here.

On the other hand, the impact on the current account and the real exchange rate is more negative with a larger share of them.

The results that show how the impact on the variables changes with the degree of wage rigidity θ_w are reported in **figure 7.** The more rigid nominal wages the smaller the impact of government spending on real wages, i.e., prices grow faster than nominal wages. Simultaneously, while the impact on consumption is slightly larger, it clearly increases more significantly on hours (employment) and is less negative on investment and the real exchange rate. Also, when wages are more rigid, inflation and the real interest rate grow less after the shock. The current account balance decreases, but not significantly.

3.3.2 Policy parameters

In **figure 8,** we report how the impact of the shock on each variable varies with the composition of government expenditures α_G. The more the government spends on domestic goods the larger its impact on aggregate consumption, GDP, employment, inflation and the interest rate, no matter which of the three rules is in place. At the same time, the impact of the shock on the current account is less negative, given that each time the government is spending less on imported goods. Where the rules differ most is in the impact of the shock on investment. In fact, with the endogenous spending rule, the impact of the shock on investment is more negative than with the other rules, even though in all cases the negative effect decreases whenever the local component of goverment spending grows. Two elements play a role regarding the impact on investment: the real interest rate, and the price of capital. Under this specific rule, the demand for capital and its price are smaller at impact, discouraging investment[14].

The relation between the size of the impact of the shock on the variables and the coefficients in the monetary rule (ϕ_π and ϕ_y) are shown in **figures 9** and **10,** respectively. The results show the interaction between monetary and fiscal policies. For instance, the more aggressive the central bank is fighting inflation (larger ϕ_π), the smaller is the impact of the government spending shock on consumption and more negative is the impact on investment. In this case, the impact of the shock on the real interest rate is obviously larger. Consistently with the latter, the impact of the shock gets smaller each time, in the case of inflation, and more negative in the

[14] To some extent, capital is substituted for labor, given that real wages are also lower in this case than with the other two rules.

case of the real exchange rate (**figure 9**). When the rule with endogenous tax rates is in place, figure **9** shows that even with a strong reaction to inflation (larger ϕ_π) the impact of the shock on GDP is still large, making it more difficult for monetary authorities to get close to a flexible price equilibrium allocation. We believe that is a consequence of the introduction of wages rigidity in the model[15].

If monetary policy cares more about stabilizing output (larger ϕ_y), the impact of the spending shock on GDP is smaller i.e. authorities dislike deviations of output from potential (steady state) even if they are positive (**figure 10**). As a consequence, interest rates move strongly upwards in order to counteract the aggregate demand hike, reducing consumption, investment, the real exchange rate, employment and inflation. On the contrary, each time we increase the coefficient ϕ_y, the impact of the shock on real wages is more positive due to the deflation that the policy reaction engineers. This exercise confirms what we said above: the impact of the spending shock on GDP and consumption is larger when the fiscal regime in place is the one with endogenous taxes. However, we also know from above, that with this rule the effect on consumption is less persistent than in the case of a fiscal regime with endogenous spending, because tax growth counteracts the wealth effect and distorts consumption.

The sensibility of the results to changes in the parameters of the fiscal rules, only apply to the rule where tax rates react endogenously to what happens with spending ϕ_g and the level of the debt ϕ_b. The larger those parameters, the faster the economies return to equilibrium. In other words, the fiscal authority is more intolerant to deficit or debt levels deviating from equilibrium. In **figure 11**, this rule is equivalent to the one that always keeps the budget balanced when ϕ_g=1. If ϕ_g>1,the fiscal authority reacts more than what is needed to close the deficit, which results in reduced consumption and GDP. **Figure 12** shows that the impact multipliers of consumption, investment and output grow slightly with ϕ_b. Therefore, a small ϕ_g combined with a large ϕ_b produces a larger response of consumption and output to the shock, as was also found by Galí et al. (2005).

4 Summary and Conclusions

We build a general equilibrium (business cycle) model of a small open economy, that includes rule-of-thumb consumers, and sticky prices and wages as well as dis-

[15] Galí et al. (2005) and in particular Blanchard and Galí (2005) discuss this issue extensively.

tortionary taxes. The economic structure is used to study the effects of government spending under three different fiscal regimes by: i) comparing the responses of the variables to government spending shock, with and without distortionary taxation; ii) running a set of exercises to see the change of the initial impact of the shock on the variables when the value of several parameters of the model are purposively modified within a range (one at a time).

The first rule-based fiscal regime keeps the budget balanced at all times. In the second, taxes react endogenously to both government spending and the level of debt. The third fiscal rule roughly mimics the one in place in Chile since 2001. With this rule, spending reacts slowly to any deviation from fiscal balance, leading to the fiscal deficit being strongly countercyclical.

Being this a small open economy, the impact of government spending on consumption and other variables changes with the value of the respective price elasticity of exports and imports (trade balance). In other words, the effects of the spending shock depend on the Marshall-Lerner conditions. If exports are more elastic, the impact of government spending on consumption, output and the current account is smaller. This last result is consistent with the traditional conclusion based on the Mundell-Fleming model about open economies with flexible exchange rates. In this case, government spending is less efficient than monetary policy expanding the economy. In addition, a sensibility analysis shows that the positive reaction of consumption to the government spending shock grows with the share of rule-of-thumb consumers and the proportion of domestic goods included in government expenditures.

Moreover, the positive effect of the spending shock on consumption is more persistent with the rule that slowly adjust spending than with the rule that increases tax rates to close the debt-financed deficit. The latter rule quickly offsets the initial wealth effect on rule-of-thumb households by raising taxes.The results also show that the response of consumption is larger when taxes are lump-sum than when they are distortionary.

The sensibility analysis shows that the degree of wage rigidity affects the impact of the shock on consumption only marginally. On the contrary, when wages are more rigid the impact of the government spending hike on investment, hours, inflation and the real exchange rate increases more significantly. Finally, the more aggressive is the central bank fighting inflation, the smaller is the impact of the government spending shock on consumption and the more negative is the impact on investment.

In conclusion, our analysis shows that the most important factors influencing the effect of government spending on consumption, investment, the current account, and GDP are: the presence of rule-of-thumb consumers, the price elasticity of exports and imports (Marshall-Lerner conditions), the share of domestic goods in government consumption, the presence of distortionary taxes, and the fiscal and monetary rules.

5 Appendix: Linearized Model

For the solution of the model we linearize the model equations around a non-stochastic steady state.

The consumption equations for Ricardian and rule-of-thumb households are given by

$$c_t^o = c_{t+1}^o - \frac{1}{\sigma}(r_t - \pi_{t+1}) + \frac{1}{\sigma}\frac{\phi}{(1+\phi)}\Delta\phi_{t+1}$$

$$c_t^r = \frac{WN}{PC}\left(\frac{1-\tau}{1+\phi}\right)\left((w_t - p_t) + n_t - \left(\frac{\tau}{1-\tau}\right)\tau_t - \left(\frac{\phi}{1-\phi}\right)\phi_t\right)$$

Then, aggregate consumption is given by

$$c_t = \lambda c_t^r + (1-\lambda)\, c_t^o$$

The supply of labor with sticky wages is given by

$$\begin{aligned}(w_t - p_t) \quad = \quad & \frac{\beta}{1+\beta}(w_{t+1} - p_{t+1}) + \frac{1}{1+\beta}(w_{t-1} - p_{t-1}) \\ & - \left(\frac{1}{1+\beta}\frac{(1-\beta\xi_w)(1-\xi_w)}{\left(1+\frac{(1+\theta_w)\varphi}{\theta_w}\right)\xi_w}\right) * \\ & \left[(w_t - p_t) - \left(\frac{\phi}{1+\phi}\right)\phi_t - \left(\frac{\tau}{1-\tau}\right)\tau_t - \varphi n_t - \sigma c_t\right]\end{aligned}$$

For the optimizing investment firms, the investment equation is given by:

$$q_t^o - \eta\,(i_t^o - k_t^o) = \left(p_t^I - p_t\right)$$

The corresponding q equation is given by:

$$q_{t+1}^{o} = \beta q_{t+1}^{o} + (1 - \beta(1-\delta))(r_{t+1}^{k} - p_{t+1}) - (r_t - \pi_{t+1})$$

Capital accumulation is standard:

$$k_{t+1}^{o} = k_t^{o} + \delta(i_t^{o} - k_t^{o})$$

Aggregation for investment and capital can be written as:

$$i_t = i_t^{o}$$

$$k_t = k_t^{o}$$

The goods-market equilibrium condition is:

$$y_t^D = \frac{C^D}{Y^D} c_t^D + \frac{I^D}{Y^D} i_t^D + \frac{G^D}{Y^D} g_t^D + \frac{X^D}{Y^D} x_t^D$$

where the components for the demand are:

$$c_t^D = -\eta_C \left(p_t^D - p_t\right) + c_t$$

$$i_t^D = -\eta_I \left(p_t^D - p_t^I\right) + i_t$$

$$g_t^D = -\eta_G \left(p_t^D - p_t^G\right) + g_t$$

and exports are given by

$$x_t^D = -\eta^* \left(\left(p_t^D - p_t\right) - (s_t - p_t) - p_t^{D*}\right) + c_t^{D*}$$

The budget constraint for the economy is:

$$
\begin{aligned}
\frac{C}{Y}c_t \quad = \quad & -\frac{P^G}{P}\frac{G}{Y}\left(p_t^G - p_t\right) - \frac{P^G}{P}g_t - \frac{P^I}{P}\frac{I}{Y}\left(p_t^I - p_t\right) \\
& \left(\frac{P^D}{P}\right)\left(\frac{Y^D}{Y}\right)\left(\left(p_t^D - p_t\right) + y_t^D\right) \\
& + \left(\frac{P^F}{P}\right)\left(\frac{Y^M}{Y}\right)\left(\left(p_t^F - p_t\right) + y_t^M\right) \\
& - \left(\frac{S}{P}\right)\left(\frac{Y^M}{Y}\right)P^{F*}\left(\left(s_t - p_t\right) + p_t^{F*} + y_t^M\right) \\
& + \left(\frac{SB^*}{PY}\right)\left(\frac{1}{1+r}\right)\left(\left(s_t - p_t\right) + b_{t+1}^* - r_t^* + \rho\widehat{\Phi}_t\right) \\
& - \left(\frac{SB^*}{PY}\right)\left(\frac{1}{1+r}\right)\left(\left(s_t - p_t\right) + b_t^*\right)
\end{aligned}
$$

We assume a risk premium of the form:

$$\widehat{\Phi}_t = b_{t+1}^* + du * \left(s_t - p_t\right) - du * y_t$$

Imports are given by

$$y_t^F = \frac{C^F}{Y^F}c_t^F + \frac{I^F}{Y^F}i_t^F + \frac{G^F}{Y^F}g_t^F$$

where the components for the imports are:

$$c_t^F = -\eta_C\left(p_t^F - p_t\right) + c_t$$

$$i_t^F = -\eta_I\left(p_t^F - p_t^I\right) + i_t$$

$$g_t^F = -\eta_G\left(p_t^F - p_t^G\right) + g_t$$

The production function can be expressed as:

$$y_t = a + \varphi_c k_t + \left(1 - \varphi_c\right) n_t$$

Uncovered interest parity condition is:

$$r_t - \pi_{t+1} = \left(\left(s_{t+1} - p_{t+1}\right) - \left(s_t - p_t\right) + r_t^* + \rho\widehat{\Phi}_t\right)$$

Real interest rate (ex-ante) is defined as

$$r\_ex_t = r_t - \pi_{t+1}$$

Inflation of domestic goods corresponds to the standard New-Keynesian Phillips curve:

$$\pi_t^D = \beta\pi_{t+1}^D + (1-\beta\theta)\frac{(1-\theta)}{\theta}mc_t^D$$

where domestic marginal costs are given by

$$mc_t^D = \varphi_m\left(r_t^k - p_t\right) + (1-\varphi_m)\left(w_t - p_t\right) - a_t - \left(p_t^D - p_t\right)$$

We assume that the inflation equation for imported goods is also given by the standard new-Keynesian Phillips curve:

$$\pi_t^F = \beta\pi_{t+1}^F + (1-\beta\theta)\frac{(1-\theta)}{\theta}mc_t^F$$

where the marginal cost of imports is determined by

$$mc_t^F = (s_t - p_t) + p_t^{F*} - \left(p_t^F - p_t\right)$$

In order to solve the model we need to define the following relative prices:

Price of domestic vs. consumption good.

$$\left(p_t^D - p_t\right) = \frac{(1-\gamma_C)\left(\frac{P^F}{P^D}\right)^{(1-\eta_C)}}{\left(\gamma_C + (1-\gamma_C)\left(\frac{P^F}{P^D}\right)^{(1-\eta_C)}\right)}\left(p_t^D - p_t^F\right)$$

Price of domestic vs. investment good.

$$\left(p_t^D - p_t^I\right) = \frac{(1-\gamma_I)\left(\frac{P^F}{P^D}\right)^{(1-\eta_I)}}{\left(\gamma_I + (1-\gamma_I)\left(\frac{P^F}{P^D}\right)^{(1-\eta_I)}\right)}\left(p_t^D - p_t^F\right)$$

Price of domestic vs. government-expenditure good.

$$\left(p_t^D - p_t^G\right) = \frac{(1-\gamma_G)\left(\frac{P^F}{P^D}\right)^{(1-\eta_G)}}{\left(\gamma_G + (1-\gamma_G)\left(\frac{P^F}{P^D}\right)^{(1-\eta_G)}\right)}\left(p_t^D - p_t^F\right)$$

Price of imports vs. consumption good.

$$\left(p_t^F - p_t\right) = \frac{-\left(\gamma_C\right)\left(\frac{P^F}{P^D}\right)^{(1-\eta_C)}}{\left(\gamma_C\left(\frac{P^F}{P^D}\right)^{(1-\eta_C)} + (1-\gamma_C)\right)}\left(p_t^D - p_t^F\right)$$

Price of import vs. investment good.

$$\left(p_t^F - p_t^I\right) = \frac{-\left(\gamma_I\right)\left(\frac{P^F}{P^D}\right)^{(1-\eta_I)}}{\left(\gamma_I\left(\frac{P^F}{P^D}\right)^{(1-\eta_I)} + (1-\gamma_I)\right)}\left(p_t^D - p_t^F\right)$$

Price of import vs. government good.

$$\left(p_t^F - p_t^G\right) = \frac{-\left(\gamma_G\right)\left(\frac{P^F}{P^D}\right)^{(1-\eta_G)}}{\left(\gamma_G\left(\frac{P^F}{P^D}\right)^{(1-\eta_C)} + (1-\gamma_G)\right)}\left(p_t^D - p_t^F\right)$$

Price of domestic vs. import good.

$$\left(p_t^D - p_t^F\right) = \left(p_{t-1}^D - p_{t-1}^F\right) + \pi_t^D - \pi_t^F$$

Price of investment vs. consumption good.

$$\left(p_t^I - p_t\right) = -\left(p_t^D - p_t^I\right) + \left(p_t^D - p_t\right)$$

Price of government vs. consumption good.

$$\left(p_t^G - p_t\right) = -\left(p_t^D - p_t^G\right) + \left(p_t^D - p_t\right)$$

Cost minimization implies:

$$\left(w_t - p_t\right) - \left(r_t^k - p_t\right) = \left(\frac{1}{\sigma_s}\right)\left(k_t - n_t\right)$$

Aggregate inflation is given by:

$$\pi_t = \chi\pi_t^F + (1-\chi)\,\pi_t^D$$

GDP can be written as:

$$
\begin{aligned}
y_t &= \left(\frac{P^D}{P}\right)\left(\frac{Y^D}{Y}\right)\left(\left(p_t^D - p_t\right) + y_t^D\right) + \left(\frac{P^F}{P}\right)\left(\frac{Y^F}{Y}\right)\left(\left(p_t^F - p_t\right) + y_t^F\right) \\
&\quad -\left(\frac{S}{P}\right)\left(\frac{Y^F}{Y}\right) P^{F*}\left(\left(s_t - p_t\right) + p_t^{F*} + y_t^D\right)
\end{aligned}
$$

We add the following monetary policy rule

$$r_t = r + \phi_\pi \pi_t + \phi_\pi y_t + u_t^r$$

The cases for the fiscal policy are

Case 1 where $\psi = \omega = 1$. The rules is given by:

$$
\begin{aligned}
\psi \frac{C}{Y}\left(\phi_t + c_t\right) &= -\tau\left(\frac{P^D}{P}\right)\left(\frac{Y^D}{Y}\right)\left(\tau_t + y_t\right) + \delta \frac{K}{Y}\left(\frac{P^I}{P}\right)\left(\tau_t + \left(p_t^I - p_t\right) + i_t^o\right) \\
&\quad -\tau\left(\frac{P^F}{P}\right)\left(\frac{Y^F}{Y}\right)\left(\tau_t + \left(p_t^F - p_t\right) + y_t^F\right) \\
&\quad +\tau\left(\frac{E}{P}\right)\left(\frac{Y^F}{Y}\right)\left(\tau_t + \left(e_t - p_t\right) + p_t^{F*} + y_t^F\right) \\
&\quad +\phi_b b_t + \phi_g g_t + \phi_g\left(\frac{G}{Y}\right)\left(\frac{P^G}{P}\right)\left(p_t^G - p_t\right)
\end{aligned}
$$

In this case government expenditure and income tax are exogenous, they evolve according to a first order autoregressive processes:

$$g_t = \rho_g g_{t-1} + \epsilon_t^g$$

$$\tau_t = \rho_\tau \tau_{t-1} + \epsilon_t^\tau$$

Case 2 where $\psi = \omega = 0$. The rules is given by:

$$\left(\frac{P^G}{P}\right)\left(\frac{G}{Y}\right)\left(p_t^G - p_t\right) + \left(\frac{P^G}{P}\right) g_t = -\frac{\phi_b}{\phi_g} b_t + u_t^g$$

In this case both taxes follow a first order autoregressive process:

$$\tau_t = \rho_\tau \tau_{t-1} + \epsilon_t^\tau$$

$$\phi_t = \rho_\phi \phi_{t-1} + \epsilon_t^\phi$$

Additionally we suppose a shock for the fiscal rule associated with government expenditure:

$$u_t^g = \rho_g u_{t-1}^g + \epsilon_t^g$$

Case 3 where $\psi = \omega = \phi_g = 1$ and $\phi_b = 0$.The fiscal rule is given by the government budget constraint because we assume a balanced budget at all times:

$$\begin{aligned}
\left(\frac{P^G}{P}\right)\left(\frac{G}{Y}\right)\left(p_t^G - p_t\right) + \left(\frac{P^G}{P}\right) g_t \quad = & \\
& \psi \frac{C}{Y}\left(\phi_t + c_t\right) + \tau \left(\frac{P^D}{P}\right)\left(\frac{Y^D}{Y}\right)\left(\tau_t + y_t\right) \\
& -\delta \frac{K}{Y}\left(\frac{P^I}{P}\right)\left(\tau_t + \left(p_t^I - p_t\right) + i_t^o\right) \\
& +\tau \left(\frac{P^F}{P}\right)\left(\frac{Y^F}{Y}\right)\left(\tau_t + \left(p_t^F - p_t\right) + y_t^F\right) \\
& -\tau \left(\frac{E}{P}\right)\left(\frac{Y^F}{Y}\right)\left(\tau_t + \left(e_t - p_t\right) + p_t^{F*} + y_t^F\right)
\end{aligned}$$

where income tax and government expenditure also evolve according to first order autoregressive processes:

$$g_t = \rho_g g_{t-1} + \epsilon_t^g$$

$$\tau_t = \rho_\tau \tau_{t-1} + \epsilon_t^\tau$$

In each case the fiscal deficit is defined as:

$$
\begin{aligned}
\text{deficit} \;=\; & \left(\frac{P^G}{P}\right)\left(\frac{G}{Y}\right)\left(p_t^G - p_t\right) + \left(\frac{P^G}{P}\right) g_t \\
& -\psi \frac{C}{Y}\left(\phi_t + c_t\right) - \tau\left(\frac{P^D}{P}\right)\left(\frac{Y^D}{Y}\right)\left(\tau_t + y_t\right) \\
& +\delta \frac{K}{Y}\left(\frac{P^I}{P}\right)\left(\tau_t + \left(p_t^I - p_t\right) + i_t^o\right) \\
& -\tau\left(\frac{P^F}{P}\right)\left(\frac{Y^F}{Y}\right)\left(\tau_t + \left(p_t^F - p_t\right) + y_t^F\right) \\
& +\tau\left(\frac{E}{P}\right)\left(\frac{Y^F}{Y}\right)\left(\tau_t + \left(e_t - p_t\right) + p_t^{F*} + y_t^F\right)
\end{aligned}
$$

Other exogenous shocks evolve according to first order autoregressive processes as well:

External interest rate shock.

$$r_t^* = \rho_{r^*} r_{t-1}^* + \epsilon_t^{r^*}$$

Monetary policy shock.

$$u_t^r = \rho_r u_{t-1}^r + \epsilon_t^r$$

Foreign price shock.

$$p_t^{F*} = \rho_{p^{F*}} p_{t-1}^{F*} + \epsilon_t^{p^{F*}}$$

External demand for domestic good shock.

$$c_t^{D*} = \rho_{c^{D*}} c_{t-1}^{D*} + \epsilon_t^{c^{D*}}$$

Foreign price of the domestically-produced export.

$$p_t^{D*} = \rho_{p^{F*}} p_{t-1}^{D*} + \epsilon_t^{p^{D*}}$$

Technology shock.

$$a_t^t = \rho_a a_{t-1}^t + \epsilon_t^a$$

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7 Tables

Table 1: Baseline Parameters

Discount factor	β	0.99
Risk aversion coefficient	σ	1.00
Weight of rule-of-thumb consumers	λ	0.50
Rate of depreciation	δ	0.02
Elasticity of investment with respect to Tobin's Q	η	1.00
Elasticity of substitution across intermediate goods	$\varepsilon_D, \varepsilon_F$	6.00
Parameter of CES production function	α	0.33
Fraction of firms that keep their prices unchanged	θ_D, θ_F	0.75
Fraction of wages that remain unchanged	ξ_w	0.75
Elasticity of substitution across hours worked	θ_w	6.0
Elasticity of substitution between capital and labor	σ_s	1.00
Response of monetary authority to inflation	ϕ_π	1.50
Response of monetary authority to output	ϕ_y	0
Response of fiscal authority to government spending	ϕ_g	0.12
Response of fiscal authority to public debt	ϕ_b	0.30
Autoregressive coefficient government expenditure shock	ρ_g	0.90
Autoregressive coefficient lump-sum taxes shock	ρ_u	0.90
Autoregressive coefficient monetary shock	ρ_r	0.70
Weight of domestic good in consumption	α_c	0.75
Weight of domestic good in investment	α_I	0.50
Weight of domestic good in government expenditure	α_G	0.90
Foreign-domestic good (consumption) elasticity of substitution	η_C	0.99
Foreign-domestic good (investment) elasticity of substitution	η_I	0.99
Foreign-domestic good (government) elasticity of substitution	η_G	0.99
Government domestic to external debt ratio	$\frac{1}{\upsilon_b} = \frac{B_t^G}{S_t B_t^{G*}}$	0.21
Inverse of the elasticity of work effort with respect to real wage	φ	0.2

Table 2: Steady State Values

Consumption output ratio	$\frac{C}{Y}$	0.62
External debt output ratio	$\frac{B^*}{Y}$	0.50
Investment output ratio	$\frac{I}{Y}$	0.17
Export output ratio	$\frac{X}{Y}$	0.34
Import output ratio	$\frac{Y^F}{Y}$	0.33
Government expending output ratio	$\frac{G}{Y}$	0.2

8 Figures

Figure 1: Shock to Government Spending with Distortionary Taxes

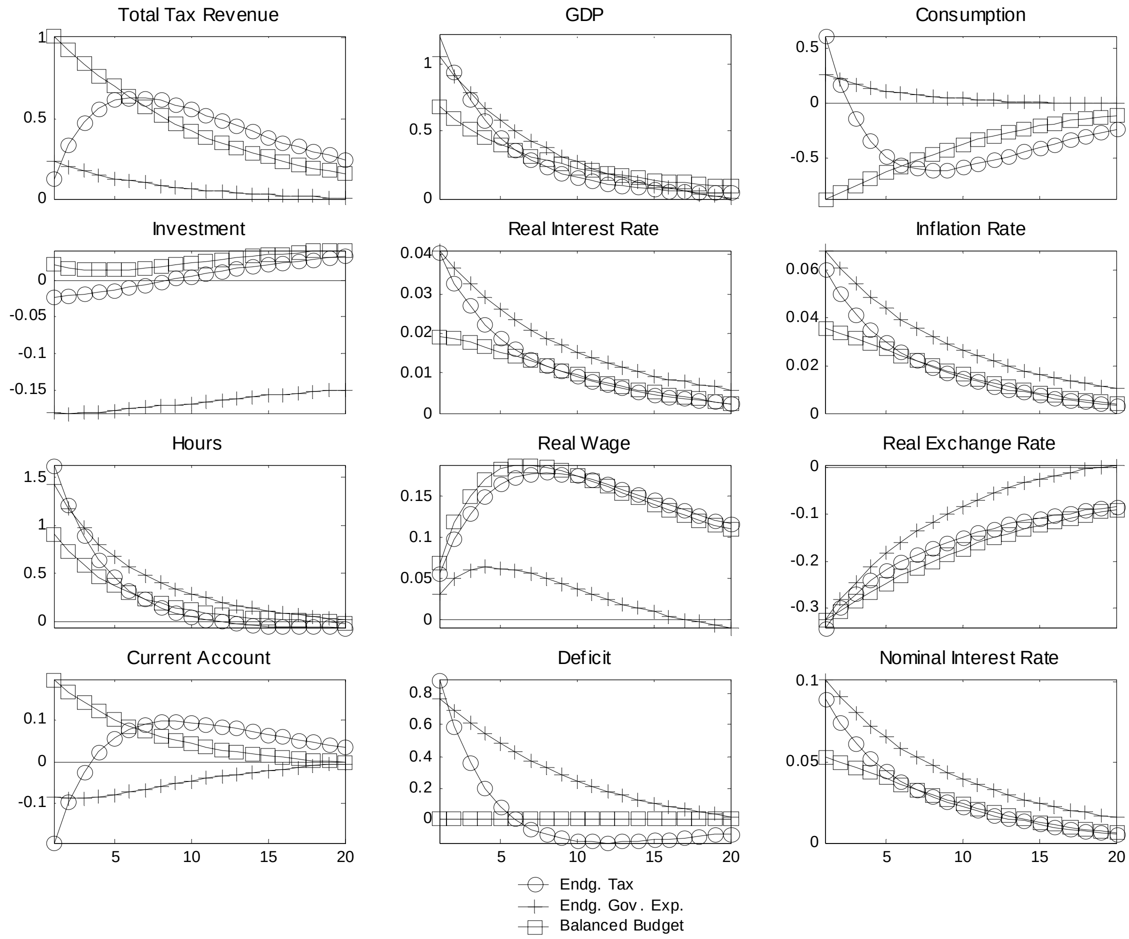

Figure 2: Impact Multipliers and Price Elasticity of Exports

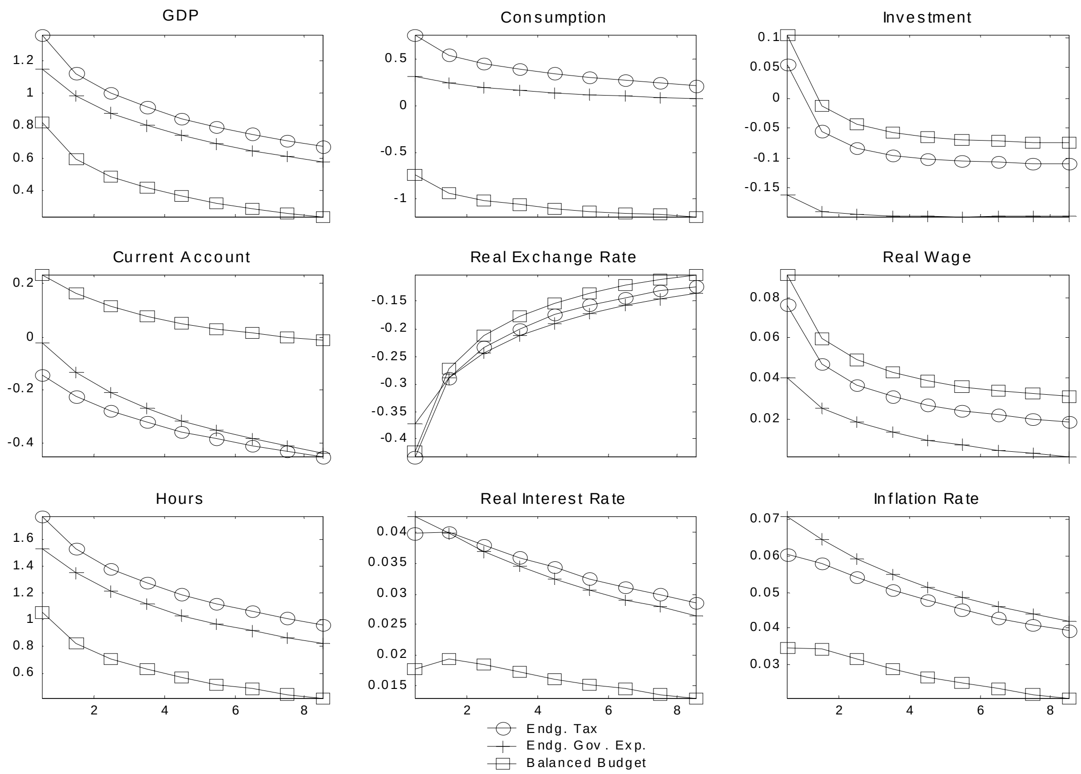

Figure 3: Impact Multipliers and Price Elasticity of Imports

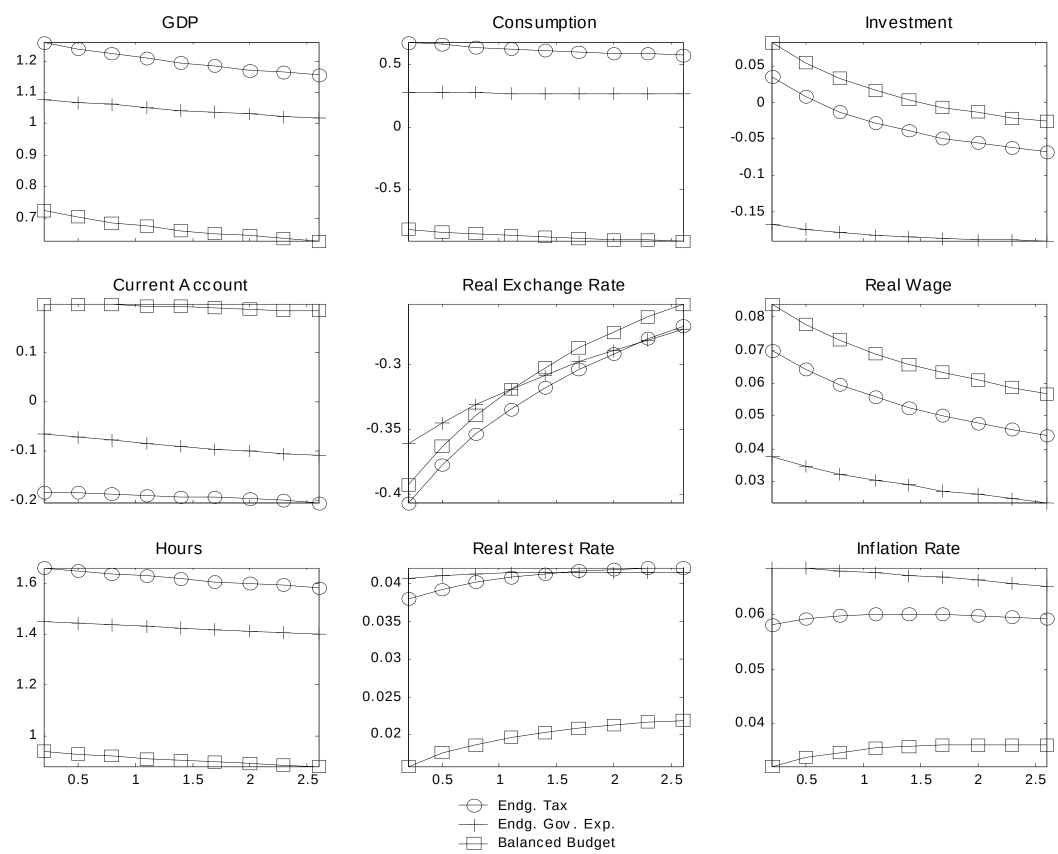

Figure 4: Impact Multipliers and Elasticity of risk Premium to Foreign Debt

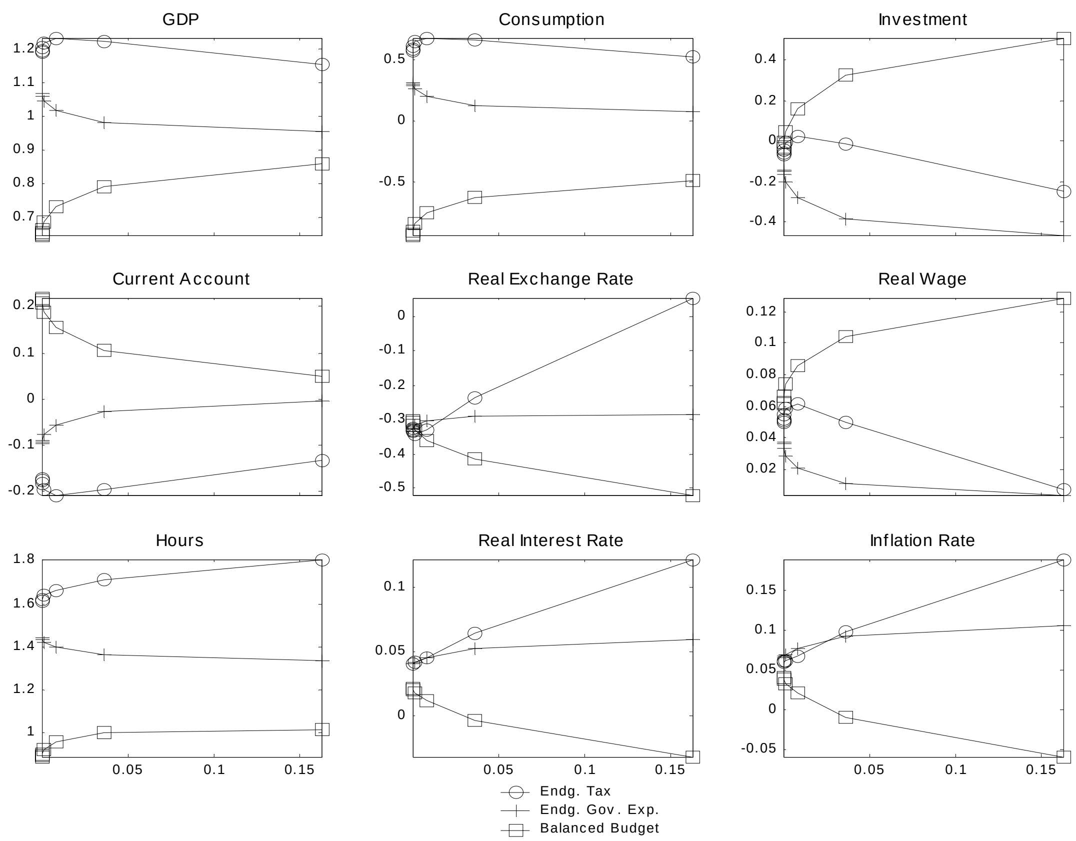

Figure 5: Shock to Government Spending with Lump Sum Taxes

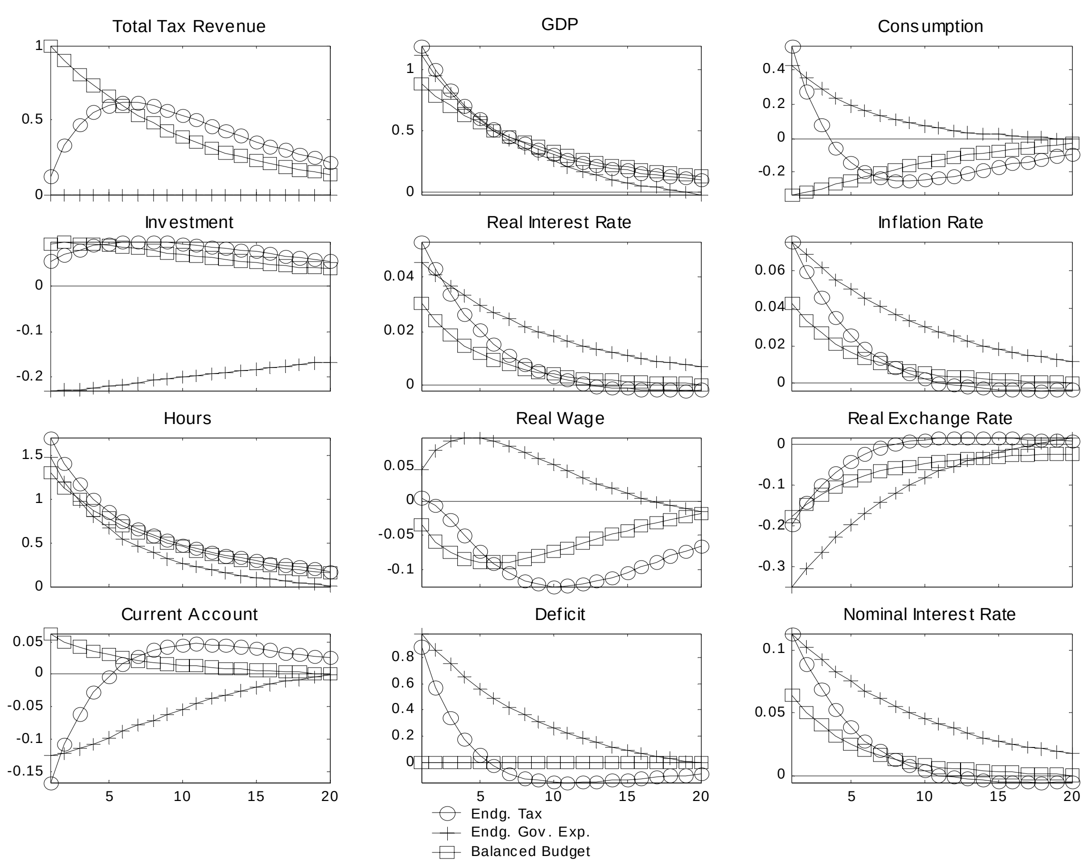

Figure 6: Impact Multipliers and Share of Rule-of-thumb Consumers

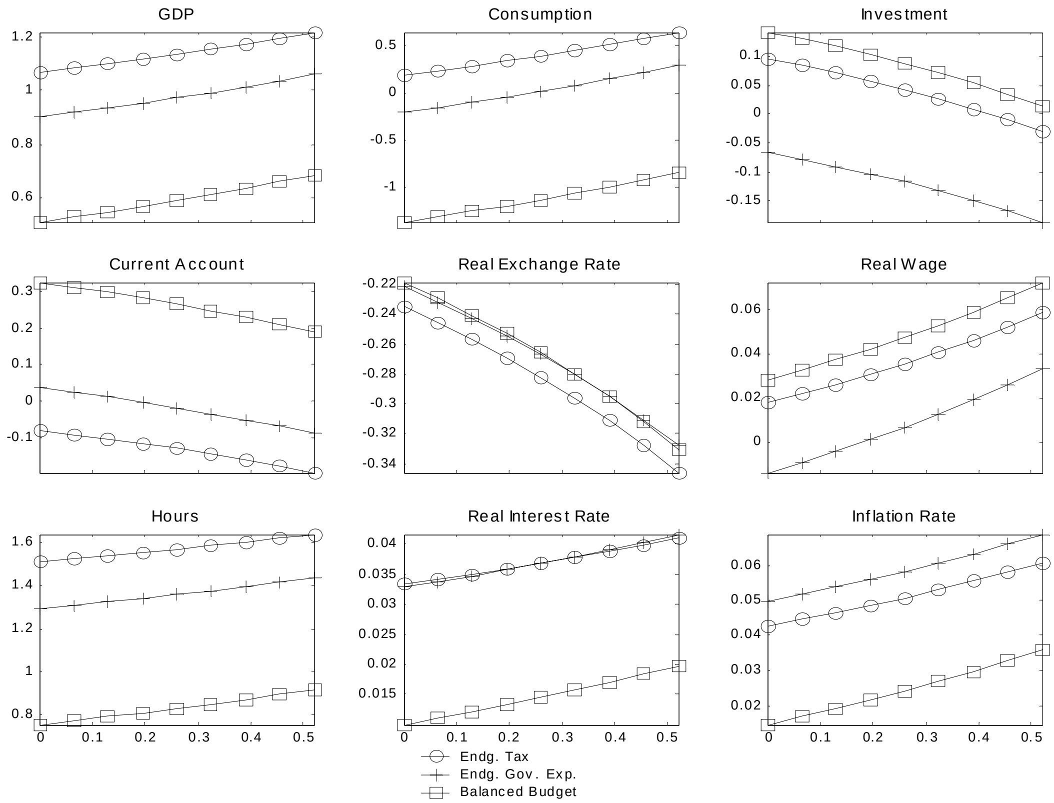

Figure 7: Impact Multipliers and Wage Rigidity

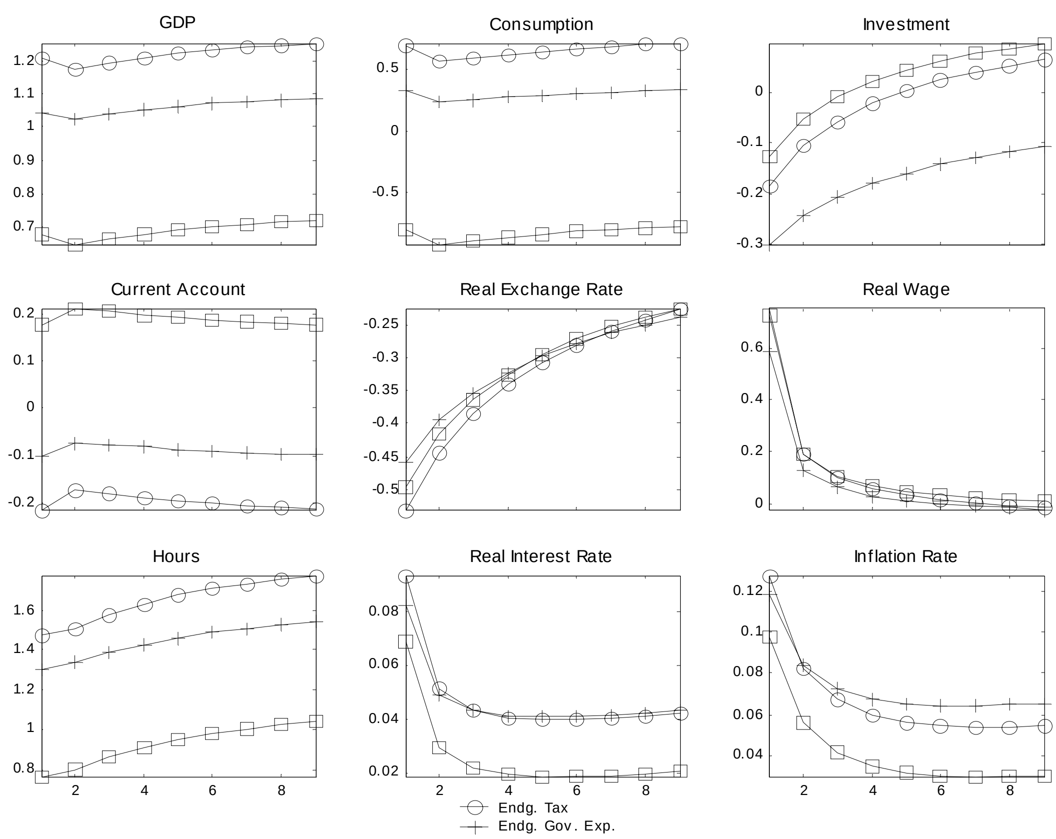

Figure 8: Impact Multipliers and Government Spending Basket

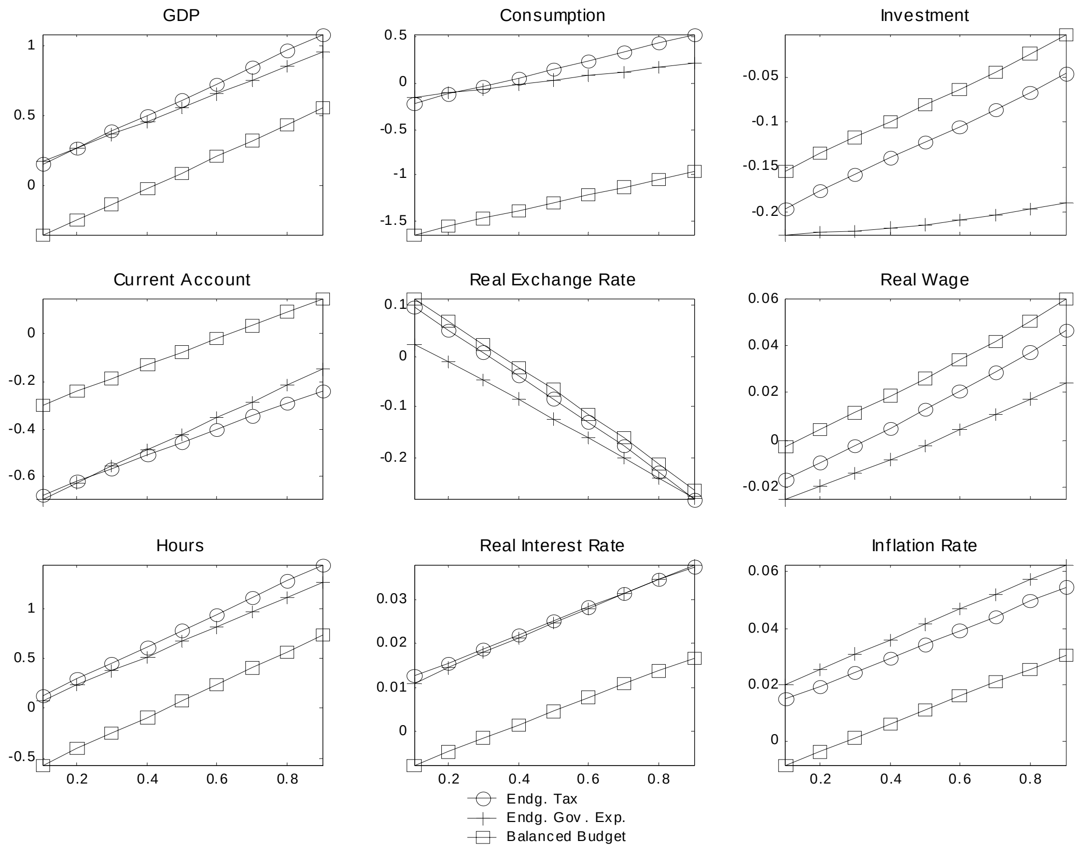

Figure 9: Taylor Rule: coefficient on inflation

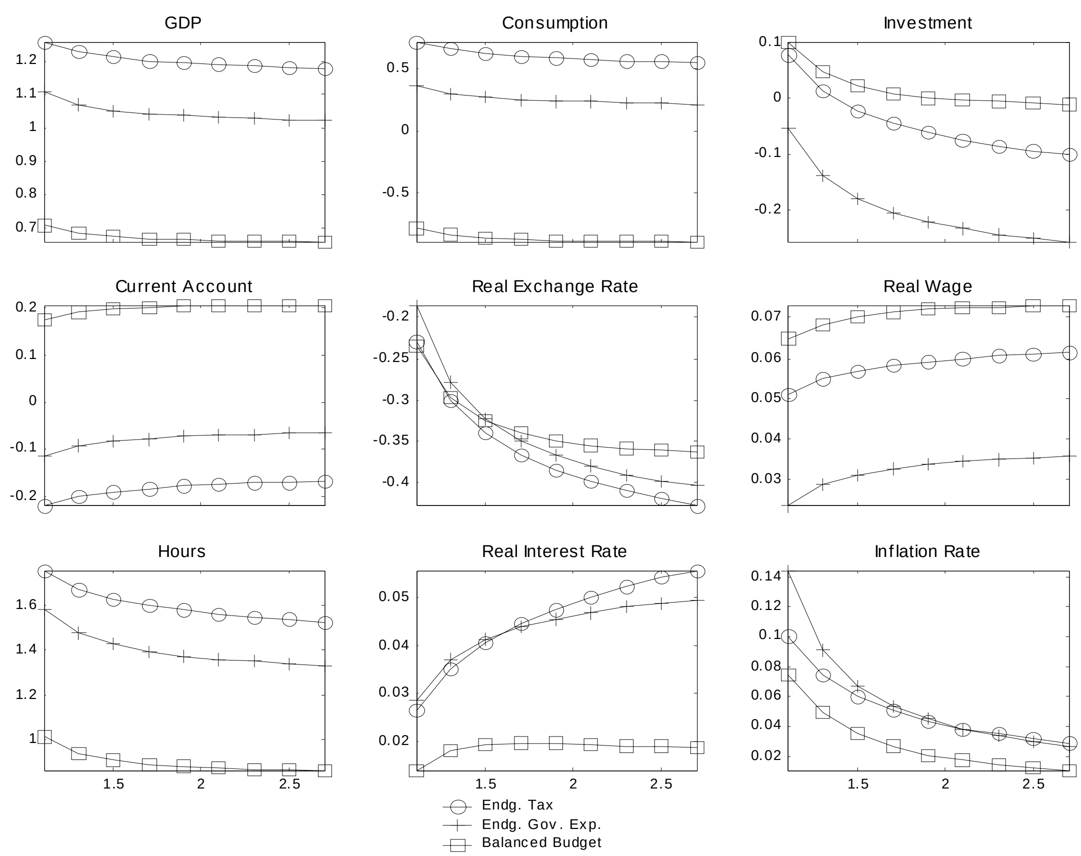

Figure 10: Taylor Rule: coefficient on output gap

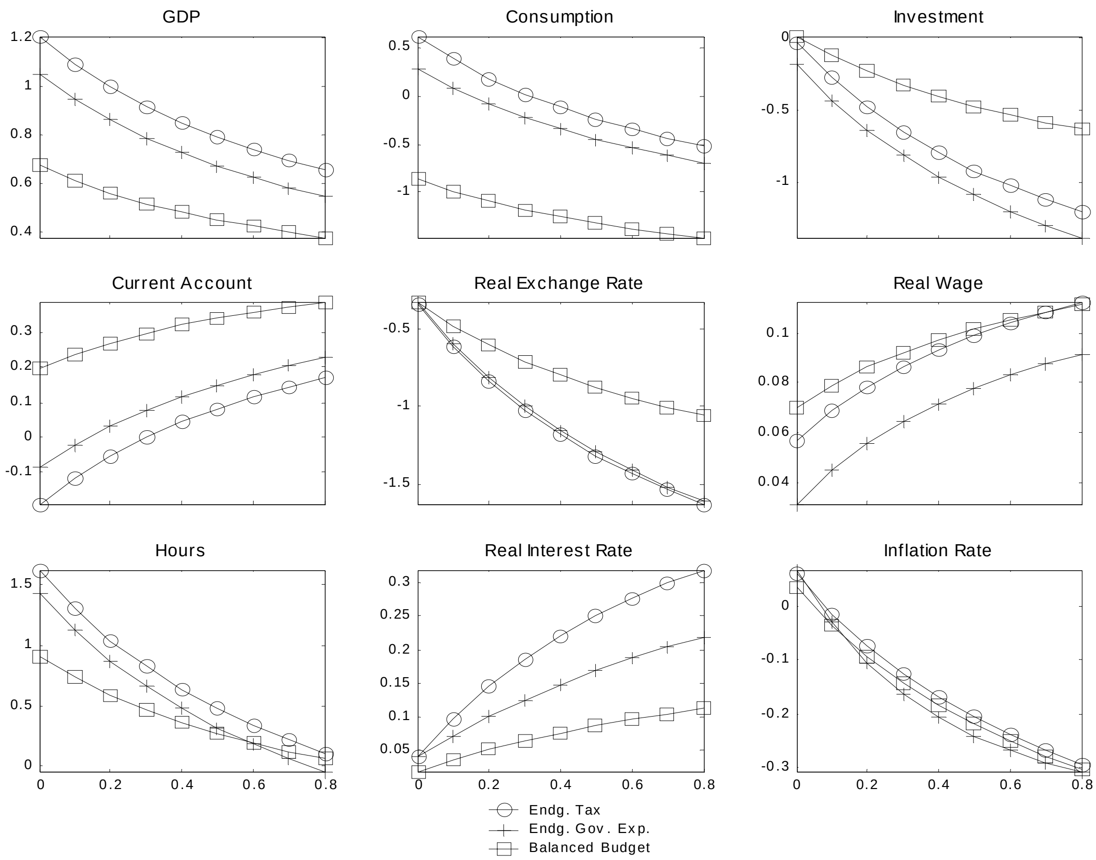

Figure 11: Fiscal Rule Government Spending Coefficient

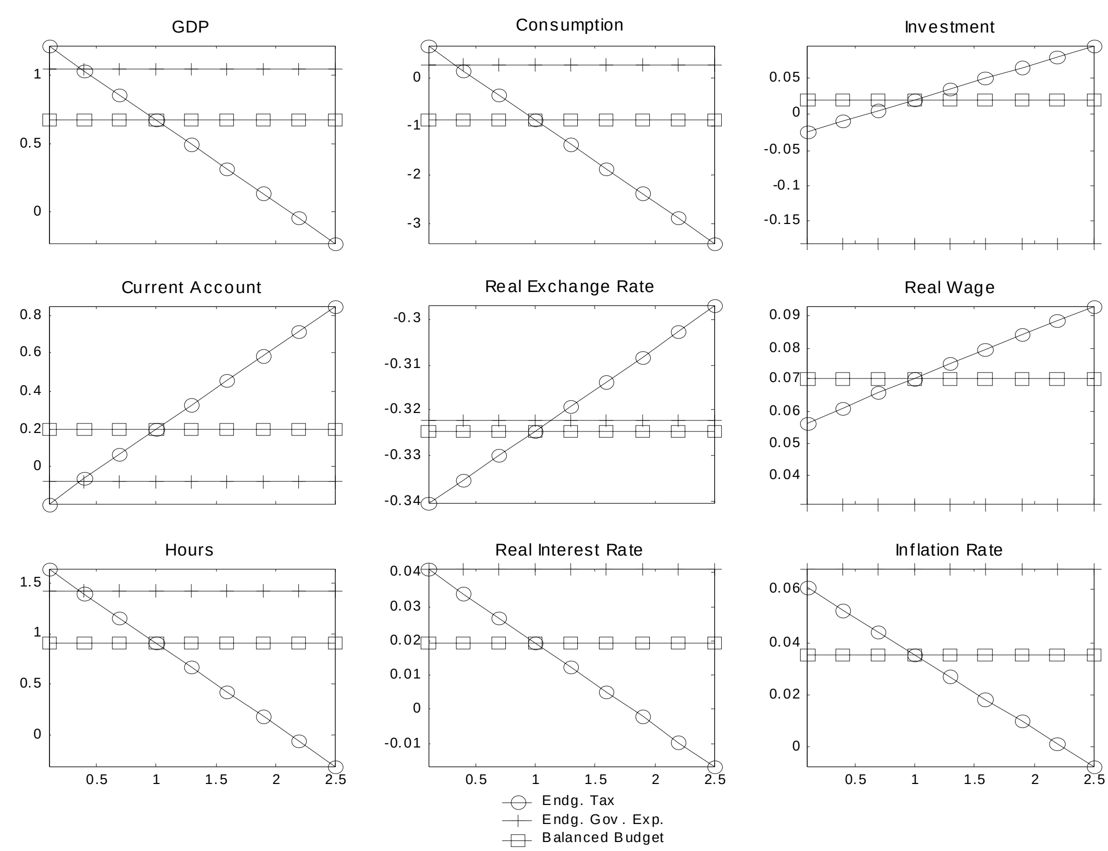

Figure 12: Fiscal Rule Government Debt Coefficient