The Case for a Countercyclical Rule-based Fiscal Regime

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Abstract

We build a general equilibrium model of a small open economy, with the purpose of analyzing the effects of a countercyclical rule-based fiscal regime, which corresponds to a stylized version of the structural balance in place in Chile. The economy exports a domestically-produced good and one natural resource (commodity), which is partly state-owned, generating income to the government. We analyze how shocks are transmitted to the economy in the presence of this fiscal rule by introducing shocks to government spending, taxes, and the price of the natural resource. In the last shock, we compare our structural rule with a case where the budget is always balanced. The results make a strong case for the adoption of the latter in other commodity-exporting economies.

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1 Introduction

Advances in business cycle theory include New Keynesian models, which allow a better understanding of macroeconomics in the presence of market imperfections i.e. monopolistic competition, sticky prices, and credit rationed (rule-of-thumb) consumers.[1] The great bulk of this literature has concentrated on analyzing the effects of monetary policy on inflation and aggregate economic activity, including among many issues: monetary shocks, Taylor rules, and uncertainty. Recently, the literature is also making quick progress regarding fiscal policy, which also includes questions of great importance to macroeconomics. Indeed, understanding the transmission to the economy of changes in fiscal policy is a requirement for policy-makers everywhere.

We build a general equilibrium model of a small open economy, with the purpose of analyzing the effects of fiscal policy.[2] The model includes lump-sum taxes, rule-of-thumb consumers, staggered prices and wages as well as a standard Taylor-type monetary rule.[3] The economy exports a domestically-produced good and a natural resource, which could be a commodity (e.g., copper, oil, coal or iron), and is partly state-owned, generating income to the government. The other part of this resource is privately owned and generates income that does not enter the country. This is actually the case of many small open economies, where the business cycle, the real exchange rate and the composition of GDP are strongly associated to the behavior of the international price of a specific commodity.[4]

Although fiscal policy can contribute to economic growth and welfare, fiscal disequilibrium and excessive discretion can be very harmful for the economy. Indeed, it can affect negatively private sector's expectations and planning horizon and the way financial markets function. Since fiscal authorities must allocate public resources, there is an inherent bias towards increasing public spending and delaying fiscal adjustment, known as the time inconsistency bias in the sense of Kidland and Prescott (1977). Such type of behavior arises because: i) authorities desire to obtain polit-

[1] This type of consumer is also called hand-to-mouth.

[2] This paper was originally part of a project to build a large Dynamic Stochastic General Equilibrium Model for the Chilean economy, which is still in progress at the Central Bank of Chile (Medina and Soto, 2006).

[3] Rigid wages are at the heart of New Keynesian models and they have been documented for many economies (Blanchard and Galí, 2005, Cuckierman, 2005).

[4] For instance, the price of copper has historically played a crucial role in the performance of the Chilean economy. On the other hand, Venezuela and Ecuador depend on the price of oil. These are only a few examples of a much longer list. **Figure 1** shows the main product as share of total exports in a group Latin American and Caribbean countries (Jiménez and Tromben, 2006).

ical dividends in the short run, leading to overspending and accumulation of debt (Alesina and Tabellini, 1990); ii) the budgetary process also suffers the tragedy of the commons because it consists of the distribution of resources with no specific owner. Since they belong to the public, each area of government tries to obtain as much as possible to spend on their preferred projects. By the same token, the members of a coalition frequently try to block any fiscal reform to avoid the political costs of its implementation (Velasco, 1994). Eventually, fiscal policy ends up being procyclical because adjustment is finally imposed by creditors in the midst of a crisis.[5]

As a matter of fact, procyclical fiscal policy in developing countries has been the rule rather than the exception (Kaminski, Reinhart, and Vegh, 2004; Talvi and Vegh, 2005). In practice, during expansions, government consumption increases and taxes fall, while the opposite is true during recessions. Furthermore, the inflation tax is also low in expansions and high in recessions. Hence, fiscal policy in those countries appears to differ substantially with respect to OECD countries.[6]

Establishing fiscal rules corresponds to an institutional solution to the time inconsistency problem guaranteeing fiscal equilibrium. Ideally, such rules should include automatic business cycle stabilizers making fiscal policy consistent with arguments in favor of smoothing public spending and taxes (Barro, 1979) as well as with traditional Keynesian proposal of counteracting costly economic fluctuations. This is precisely the case of the Chilean fiscal rule. Indeed, in 2001 the Chilean fiscal authority established that spending will be adjusted to meet the goal of a 1% structural surplus. "Structural" refers here to trend tax 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 its gradual reaction to structural revenues and/or to any deviation from the 1% structural surplus.[7]

This is why our model also includes a fiscal rule that represents a stylized version of the structural-surplus rule in place in Chile since 2001. Given that this is a

[5] Gavin et al. (1996) and Gavin and Perotti (1997) have attributed this procyclical bias to the fact that developing countries are rationed from international credit markets in bad times.

[6] Talvi, E. and C. Vegh (2005) argue that pressures to increase public spending in countries that face large fluctuations in the tax base, as is the case of many developing countries, are the cause behind running an optimal procyclical fiscal policy.

[7] The target of a 1% structural surplus was set to cover the Central Bank's deficit and future pension liabilities.

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. As a result, with our rule, spending moves with structural tax revenues (steady state) and slowly reacts to any deviation from fiscal balance, making the fiscal deficit also countercyclical.[8]

In order to analyze the transmission of the shocks to the economy with the fiscal rule, we carry out several experiments by introducing shocks to government spending, taxes, and the price of the natural resource. The spending shock results in increased consumption, GDP, real wages and imports. At the same time, there is currency appreciation. Therefore, exports of the domestically-produced good and the current account decline.[9] The latter is a standard result of open-economy models with flexible exchange rates, where net exports decrease as a consequence of public spending. Finally, due to the spending hike, inflation increases, as do the nominal and real interest rates, resulting in lower investment. These results are consistent with the traditional Mundell-Fleming (IS-LM) model and with recent micro and macro evidence on the subject for the US and other OECD countries. A non exhaustive list of recent studies include Blanchard and Perotti (2002); Mankiw (2000); Perotti (2002); Galí et al.(2005); Mountford and Uhlig (2002); Fatás and Mihov (2001) and Ramey and Shapiro (1998). On the other hand, Restrepo and Rincón (2005) perform empirical estimations for two developing economies.

In the standard RBC model, which only has Ricardian agents, an increase in government spending reduces after-tax lifetime income and consumption. In our model, on the contrary, there is a share of consumers whose decisions depend on current disposable income. Given the wealth and income distribution prevalent in the US, as well as in many countries, a share of households do no save and cannot borrow (Jaffee and Stiglitz, 1990; Mankiw, 2000). Hence, they cannot smooth consumption when income fluctuates or change the intertemporal consumption path when the interest rate moves. In this case, real wages respond positively to the spending hike, which improves rule-of-thumbers income compensating the negative wealth effect suffered by optimizing agents.

[8]For a comparison of three different fiscal rules, see García and Restrepo (2005).

[9]The impact of the shock on consumption and GDP grows with the share of rule-of-thumb consumers and domestic goods in the government's basket. On the other hand, the more aggressive the central bank in fighting inflation, the smaller the impact of the government spending shock on consumption and GDP, and the more negative the impact on investment (García and Restrepo, 2005).

The shock on lump-sum taxes has opposite effects. Consumption drops, and so do GDP, imports, the real wage, and the fiscal deficit. Similarly, inflation decreases jointly with the nominal and real interest rates, driving investment upwards. The real exchange rate goes up with exports and the current account.

The third shock corresponds to an increase in the price of the natural resource. It is assumed that in the short run its supply is given and will not increase in response to the higher price. The larger the share of the income coming from the natural resource that is brought into the country, the stronger the impact on the economy of a shock to its price: GDP, consumption, investment, and wages increase. On the other hand, the currency appreciates and exports of the domestically-produced good fall. In other words, the higher price of the natural resource generates the well-known Dutch disease. However, in comparison to the outcome using an always balanced budget, the latter effect is almost negligible, thanks to the structural fiscal rule, which is strongly countercyclical, saving the windfall and avoiding most the undesired currency appreciation and reduction of exports of the domestically-produced good. These results make a good case for implementing such type of rule in other small open commodity-exporting economies.

The article is organized as follows. Section 2 describes the model. Section 3 discusses the calibration of the parameters and analyzes the models' dynamics towards equilibrium when each shock hits the economy. Finally, section 4 summarizes the results and concludes.

2 Model

The economy corresponds to a business cycle model, which has a continuum of households and firms engaged in monopolistic competition, staggered prices and monetary (central bank) and fiscal authorities. Therefore, it is close to the so-called New Keynesian literature (Rotemberg and Woodford,1992, Clarida, Galí and Gertler,1999, Smets and Wouters, 2002). In particular, we follow Galí et al. (2005) by including the two types of households: optimizers (Ricardian) and rule-of thumbers. We also include staggered wages as in Erceg, Henderson and Levin (2000).

2.1 Households

There is a continuum of infinitely lived households indexed by $i \in [0, 1]$. A fraction of households λ consume their current labor income, do not save, and cannot borrow i.e. 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

The representative household maximizes:

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

subject to the budget constraint

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

where $C_t^o(i)$ is consumption, $D_t^o(i)$ are dividends from ownership of firms, $\Phi\left(B_t^*\right)$ represents the country risk premium, S_t is the nominal exchange rate, $B_t^*(i)$ denotes private net foreign assets, W_t is nominal wage, $N_t^o(i)$ is the number of hours of work, $B_t^o(i)$ is government debt held by households, R_t is the gross nominal return on assets, and $T_t(i)$ are lump-sum taxes.

The utility function takes the form:

$$U(C, L) = \frac{C^{1-\sigma}}{1-\sigma} - \frac{N^{1+\varphi}}{1+\varphi} \tag{3}$$

where $1/\sigma$ denotes the intertemporal elasticity of substitution in consumption and φ is the elasticity of marginal disutility to labor supply.[10]

Therefore, the first-order condition for consumption is:

$$C_t^o(i)^\sigma = \beta^{-1} E_t \left(C_{t+1}^o(i)^\sigma \frac{1}{R_t} \left(\frac{P_t}{P_{t+1}} \right) \right) \tag{4}$$

From the first order conditions it is also posible to derive the interest parity condition:

$$R_t \left(\frac{P_t}{P_{t+1}} \right) = \left(\frac{e_{t+1}}{P_{t+1}} \right) \left(\frac{P_t}{e_t} \right) R_t^* \Phi \left(\frac{e_t B_t^*}{P_t Y_t} \right)$$

[10] In our baseline calibration we assume $\sigma = 1$.Therefore, the utility function becomes: $\log(C) - (N^{1+\varphi})/(1+\varphi)$.

where e_t is the nominal exchange rate.

We have not included the first-order condition for labor supply because, following Galí et al. (2005), we assume that hours are chosen by firms. On the other hand, households supply the labor required because wages remain always above the marginal rate of substitution, given that workers have some market power.

2.1.2 Rule-of-thumb households

Utility of the credit restricted households is given by:

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

We assume that these households do no save and cannot borrow (Mankiw, 2000). As a result, their level of consumption is given by their disposable income:

$$P_t C_t^r(i) = W_t N_t^r(i) - P_t T_t. \tag{6}$$

2.1.3 The wage schedule

We suppose —as in Erceg, Henderson and Levin (2000)— that households act as price-setters in the labor market.[11] Since wages are staggered à la Calvo (1983), they can only be optimally changed after some random "signal" is received. A continuum of monopolistically competitive households supply a differentiated labor service to the intermediate-goods-producing sector and a labor aggregator combines as much household-labor as is demanded by firms, with a constant-returns technology. The aggregate labor index N_t has the CES 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 used from each household.

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

[11] Other 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 $\frac{W_t}{P_t} = H(C_t, N_t, \phi_t, \tau_t)$.

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

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

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

Wages of rule-of-thumb households are set at the average wage level of optimizing households.

2.1.4 Demand for domestic and imported consumption goods

Consumption is a CES aggregate of consumption of domestic C^D and imported goods C^F.

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

There is a demand for each set of differentiated domestic and imported goods, which is derived from expenditure minimization and given by:

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

$$C_t^F = (1 - \alpha_c) \left(\frac{P_t^F}{P_t} \right)^{-\eta_c} C_t \tag{12}$$

P_t, the aggregate consumer price index or CPI, is defined as:

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

A weighted average of a bundle of either domestic or imported differentiated goods composes each type of good, which also consists of a Dixit-Stiglitz index:

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

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

where the respective price index is:

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

for $K = D, F$.

2.2 Domestic intermediate-goods firms

We assume the existence of a continuum of monopolistically competitive firms, indexed by $j \in [0,1]$, producing differentiated intermediate goods.

2.2.1 Cost minimization

The production function of the representative intermediate-good firm, indexed by j, corresponds to a CES combination of 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, the technology parameter, and σ_s, the elasticity of substitution between capital and labor, are both ≥ 0.

The firms' costs are minimized taking as given the rental price of capital, R_t^k, and the wage, W_t, subject to the production function (technology). The relative factor demands are derived from the first-order conditions:

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

and the marginal cost is 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

When firm j receives a signal to optimally set a new price à la Calvo (1983), it 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 $\Lambda_{t,t+k}$ being equal to:

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

Firms that did not receive the signal cannot adjust their prices and those that are allowed to optimally reset their prices choose the same price P_t^{D*}. 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

This sector consists of firms that import a homogenous good produced abroad and turn it into a differentiated foreign good for the home market using a linear production technology. Import firms are only allowed to change their price when they receive a random price-change signal. Thus, the dynamics of the import price index is also described by an equation similar to (24) but, in this case, the firms that are allowed to reset their prices respond to variations in the exchange rate or the foreign price and choose as their optimal price the import price abroad expressed in domestic currency $S_t P_t^{F*}$ (Smets and Wouters, 2002).

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

It is worth pointing out that exchange rate pass-through here is partial.

2.4 Optimizing investment firms

There are firms that produce homogenous capital goods and rent them to the intermediate-goods firms. Note that only the Ricardian households own them.

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 equation, which includes adjustment costs:

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

The first-order conditions are:

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

and

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

Equation (29) corresponds to Tobin's Q, which in words states that 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.

2.4.2 Demand for investment goods

Overall investment is equal to a CES aggregate of domestic and imported goods.

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

The respective demands for domestic and imported investment goods are derived from expenditure minimization, and given by:

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

and

$$I_t^F = (1-\alpha_I) \left(\frac{P_t^F}{P_t^I} \right)^{-\eta_I} I_t. \tag{32}$$

The aggregate price of investment (investment deflator) is defined as:

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

Each composite good is itself a bundle of differentiated goods

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

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

for $K = D, F$.

The demand for domestic exports

$$X_t^D = \left[\left(\frac{P_t^D}{P_t}\right)\left(\frac{P_t}{e_t}\right)\left(\frac{1}{P_t^{D*}}\right)\right]^{-\eta*} * C_t^{D*}$$

2.4.3 Aggregation

The weighted sum of consumption by Ricardian and rule-of-thumb agents makes aggregate consumption

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

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

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

By the same token, the aggregate capital stock is equal to:

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

Again, only optimizing households hold financial assets:

$$B_t = (1-\lambda)\left(B_t^o\right). \tag{39}$$

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

$$B_t^* = B_t^{G*} + (1-\lambda)B_t^{o*}. \tag{40}$$

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

$$N_t = \lambda N_t^r + (1 - \lambda) N_t^o \tag{41}$$

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

$$N_t = N_t^r = N_t^o \tag{42}$$

2.5 Monetary policy

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

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

with $\overline{r}$ being the neutral or steady state nominal interest rate and yr_t standing for GDP without the natural resource. The coefficient on inflation is $\phi_\pi \geq 1$. Since $\phi_{yr} = 0$ in our baseline calibration, this rule is a particular case of the well-known Taylor rule, in which authorities do not include the output gap.

2.6 Fiscal policy

The government budget constraint is:

$$\begin{aligned} &P_t T_t + tau\_cu \left(S_t P_t^{cu} Q\_cu\right) \\ &\qquad + R_t^{-1} B_{t+1}^G + S_t \left(\Phi\left(B_t^*\right) R_t^*\right)^{-1} B_{t+1}^{G*} = \\ &\qquad\qquad B_t^G + S_t B_t^{G*} + P_t^G G_t \end{aligned} \tag{44}$$

where tau_cu is the share of the production of the natural resource owned by the government. P_t^{cu} denotes its international price and Q_cu is the amount produced (supplied), which is fixed. Indeed, we assume that in the short run the supply of the natural resource is limited, and will not increase in response to the higher international price.

$\Phi\left(B_t^*\right)$ represents the country-risk premium, B_t^G denotes public domestic assets (debt), R_t^* is the gross nominal return on foreign assets, $P_t T_t$ corresponds to government nominal (lump-sum) tax revenues, and $P_t^G G_t$ is public spending. For simplicity, we assume that the government maintains a fixed proportion of domestic and external debt: $S_t B_t^{G*} = \upsilon_b B_t$.

The fiscal rule establishes that public spending should be equal to steady-state (structural) government revenues $\overline{IT}$ less interest payments:

$$P_t^G G_t = \overline{IT} - \frac{i_t}{1+i_t} B_t^G - \frac{i*}{1+i_t^*} S_t B_t^{G*}. \tag{45}$$

Under this rule, the government adjusts spending, instead of taxes, to go back to equilibrium, whenever it faces 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 takes 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, the government debt follows a random walk (Restrepo, 2005). Therefore, we cannot use such a rule because the model would not converge. For that reason, we allow the debt to have some weight in the rule $\mu_x = 0.001$, so the government has to pay a little more than the interest on its debt to slowly amortize the principal and converge back to the steady-state level.

$$P_t^G G_t = \overline{IT} - \left[\frac{i_t}{1+i_t} + \frac{i_t^*}{1+i_t^*} \upsilon_b + \mu_x \right] B_t^G. \tag{46}$$

Finally, as a way of introducing shocks to the level of the tax rate, we suppose that after the shock it follows an autoregressive process:

$$\tau_t = \rho_\tau \tau_{t-1} + u_t^t. \tag{47}$$

2.6.1 Government demand for domestic and imported goods

The government demands domestic and imported goods.

$$G_t = \left(\alpha_G \left(G_t^D \right)^{\frac{\eta_G - 1}{\eta_G}} + (1-\alpha_G) \left(G_t^F \right)^{\frac{\eta_G - 1}{\eta_G}} \right)^{\frac{\eta_G}{\eta_G - 1}}. \tag{48}$$

The demands for domestic and imported goods derived from expenditure minimization are given by:

$$G_t^D = \alpha_G \left(\frac{P_t^D}{P_t^G} \right)^{-\eta_G} G_t \tag{49}$$

and

$$G_t^F = (1-\alpha_G)\left(\frac{P_t^F}{P_t^G}\right)^{-\eta_G} G_t. \tag{50}$$

The aggregate price deflator of government spending is defined as:

$$P_t^G = \left(\alpha_G \left(P_t^D\right)^{1-\eta_G} + (1-\alpha_G)\left(P_t^F\right)^{1-\eta_G}\right)^{\frac{1}{1-\eta_G}}. \tag{51}$$

Domestic and imported goods are themselves bundles of differentiated goods

$$G_t^K = \left(\int_0^1 G_t^K(j)^{\frac{\varepsilon_K-1}{\varepsilon_K}} dj\right)^{\frac{\varepsilon_K}{\varepsilon_K-1}} \tag{52}$$

$$G_t^K(j) = \left(\frac{P_t^K(j)}{P_t^K}\right)^{-\varepsilon_K} G_t^K \tag{53}$$

for $K = D, F$.

2.7 Market-clearing conditions

The factor market-clearing conditions are given by:

$$N_t = \int_0^1 N_t(j)dj \tag{54}$$

and

$$K_t = \int_0^1 K_t(j)dj \tag{55}$$

The equilibrium for the domestic market is:

$$Y_t^D(j) = \left(\frac{P_t^D(j)}{P_t^D}\right)^{-\varepsilon_D} \left(C_t^D + I_t^D + G_t^D + X_t^D\right) \tag{56}$$

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

$$Y_t^D = C_t^D + I_t^D + G_t^D + X_t^D. \tag{57}$$

Finally, the economy equilibrium can be expressed as:

$$
\begin{aligned}
P_tC_t &= -P_t^G G_t - P_t^I I_t + P_t^D Y_t^D + P_t^F Y_t^F - S_t P_t^{*F} Y_t^F \\
&+S_t \left(\Phi\left(\frac{e_t B_t^*}{P_t Y_t}\right) R_t^*\right)^{-1} B_{t+1}^* - S_t B_t^* \\
&+tau\_cu\left(S_t P_t^{cu} Q\_cu\right).
\end{aligned} \tag{58}
$$

where total imports are equal to $Y_t^F = C_t^F + I_t^F + G_t^F$

3 Calibration and Dynamics

The model is linearized (see the appendix), then the system of stochastic difference equations is solved with Dynare (Julliard, 2003).[12]

We show most of the parameters used in our calibration (Table 1).[13] For instance, the discount factor β is 0.99, which is a standard figure found in the literature. The risk aversion coefficient in the consumption function is 1. The elasticity of substitution across intermediate goods is ε=6, and the rate of depreciation δ is 0.02. Half of the households are rule-of-thumbers. Whenever there is public debt, we impose a relationship between local and foreign government debt $\left(\frac{B^G}{S_t B_t^{G*}}\right)$ of 0.21. The share of domestic goods in the government basket of consumption is α_G=0.99. In our baseline simulation, the size of the coefficient in the monetary rule with respect to inflation ϕ_π is equal to 1.5, and with respect to output ϕ_{yr} is 0. In our steady state, consumption is 63% of GDP, government spending is 20%, and given that the overall government budget is assumed to be balanced, tax revenues are also 20% (Restrepo and Soto, 2004). This is equivalent to assuming structural balance instead of the structural surplus adopted in Chile, without loss of generality. The ratio of exports to GDP is 34%, investment is 16%, 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).

3.0.1 Effects of shocks

We report in this section the results of the experiments performed with the artificial small open economy[14].

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

[13] We assume that each period corresponds to one quarter.

[14] The line with crosses corresponds to the baseline calibration in all the figures.

Fiscal spending shock We show in **figure 2** the responses of a large set of variables (18) to a government spending shock. Each response includes three lines, which correspond to a different share of rule-of-thumb households in the economy (λ). When λ is smaller, the results are closer to the ones that would be obtained by the standard real business cycle (RBC) model, which only has Ricardian households. The difference is that here prices are rigid. On the contrary, with a large share of rule-of-thumb agents (λ=0.5), the debt-financed spending shock results in increased consumption, GDP, hours of work, real wages and imports. The transmission mechanism of the shock works through higher real wages, which improves rule-of-thumbers' income compensating the negative wealth effect suffered by optimizing agents. The larger domestic demand drives up inflation and the real and nominal interest rates with a negative impact on investment. On the other hand, the currency appreciates, imports go up, while exports of the domestically-produced good decrease. The resulting current account deficit translates into a build-up of foreign debt. Even though we did not include the risk premium in the figure, it increases with debt.

The positive effect on consumption and GDP is consistent not only with the traditional IS-LM model (Blanchard, 2001) but also with recent macro evidence. Similarly, the decline of the exchange rate and the current account is in line with the traditional Mundell-Fleming model, where net exports decrease as a consequence of public spending, in a flexible exchange rate regime. The composition of GDP and/or aggregate demand changes as a result of the shock.

In **figure 3**, we include the responses of the variables to the same shock (with λ always being equal to =0.5), when the composition of domestic goods in the government consumption basket changes. The larger the share of domestic goods, the stronger the positive impact on consumption, GDP, hours of work, real wages, and the rental price of capital as well as on inflation, and the nominal and real interest rates. By the same token, the appreciation of the currency and the fall of the amount exported of the domestically-produced good are also larger.

Lump-sum tax shock The shock on lump-sum taxes has opposite effects to the ones observed when the economy is hit by an increase in government spending. As is shown in **figure 4**, consumption drops as well as GDP, imports, hours of work, real wages, the rental price of capital and the fiscal deficit. Similarly, inflation decreases jointly with the nominal and real interest rates, driving investment upwards. The real exchange rate goes up with exports of the domestically-produced good and the current account generates a surplus reducing foreign debt. Finally, the fiscal deficit narrows as expected. It is worth pointing out that in the case of a very low share of rule-of-thumb households (small λ), the effect of the shock on most variables is almost negligible. **Figure 5** includes the responses of the variables to the tax shock when the composition of the government's consumption basket varies. In this case, the fall in consumption, real wages and the rental price of capital is smaller if the government spends more on domestic goods. Similarly, investment grows more. In addition, the real exchange rate increases less when the government spends more domestically. Finally, inflation and both interest rates fall more after the tax shock with a larger share of domestically-produced goods included in the government consumption basket.

Natural resource shock The last shock consists of an increase in the international price of the natural resource sold abroad. Its supply is assumed to be given in the short run, and will not respond to the higher price. The larger the share of the natural resource income that is brought into the country, the stronger the impact of the shock on the economy. Indeed, in **figure 6** GDP, consumption, hours of work, wages and the rental price of capital all increase. Consistently with the countercyclical nature of the fiscal rule, the government deficit falls. On the other hand, the currency appreciates, imports go up, and exports of the domestically-produced good fall. In other words, higher prices of the natural resource generate the well-known Dutch disease. Finally, the appreciation of the currency slightly reduces inflation (exchange rate pass through), and also reduces both interest rates, given the monetary rule. The latter effect drives investment upwards.

The most important results are included in **figure 7**, where each small chart has two lines. The dotted line was obtained with a rule where the government's budget is balanced at all times. The line with crosses represents the responses of the variables to the same shock in our baseline model (Chilean fiscal rule). The countercyclical nature of the rule is evident. In both cases government revenues show the same jump at impact. However in our baseline model GDP and consumption only increase marginally because most resources are saved, which is reflected in a drop of the fiscal deficit. That is why government expenditure remains almost constant. Hence, the real exchange rate shows a very modest reduction and so do inflation, and interest rates. The latter effect pushes investment up. On the contrary the balanced-budget rule is strongly procyclical: government expenditures grow jointly with revenues fueling the economy. Therefore, output, consumption and hours also increase. The appreciation of the currency is larger causing a jump in imports and a larger reduction in exports of the domestically-produced good than before. In this case, inflation and both interest rates go up dampening investment. A drop in the price of the natural resource would have the opposite effects. The balanced-budget rule would accentuate its negative impact on GDP, consumption and other variables while our baseline fiscal regime would avoid most of the undesired effects. In **figure 8,** we increased the persistence of the shock from 0,7 to 0,9. The more persistent is the shock to the price of the natural resource, the larger is the real exchange rate fall (appreciation). In both cases the appreciation of the currency with the balanced budget is almost double than with the rule of structural balance. In the case of a near permanent shock the drop of the real exchange rate gets close to 20% of the copper price hike, and the difference between both rules decreases because additional revenues are quasi-permanent or quasi-structural (table 3).

4 Summary and Conclusions

We have built a general equilibrium model of a small open economy, with the purpose of analyzing the effects of fiscal policy. The model includes lump-sum taxes, rule-of-thumb consumers, sticky prices, and staggered wages. The economy exports a domestically-produced good and one natural resource, which is partly owned by the government. The other part of this resource belongs to the private sector and never enters the country. The model also has a standard Taylor-type monetary rule and a fiscal rule that represents a stylized version of the structural surplus in place in Chile during the last five years. With this rule, the fiscal deficit is countercyclical, given that spending should be in line with structural revenues (trend tax revenues), and it slowly reacts to any deviation from fiscal balance. We assumed that our steady-state fiscal balance corresponded to the structural one. We introduced shocks to government spending, taxes, and the price of the natural resource. In general, we conclude that the results obtained with the experiments are very intuitive and consistent with both common economic wisdom and empirical evidence.

The spending shock resulted in increased consumption, GDP, real wages and imports. In this case, real wages responded positively to the larger spending, which improved rule-of-thumbers' income, thus compensating the negative wealth effect suffered by optimizing agents. Therefore, 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. At the same time, the currency appreciated, exports of the domestically-produced good fell and the current account decreased. These results are consistent with the traditional Mundell-Fleming model (IS-LM-BP) and also with recent macro evidence. Finally, the increase in government spending fueled inflation and pushed the nominal and real interest rates up, affecting investment negatively.

The shock on lump-sum taxes had opposite effects. Consumption dropped, as did GDP, imports, real wages, and the fiscal deficit. Similarly, inflation fell jointly with the nominal and real interest rates, driving investment upwards. The real exchange rate went up with exports and the current account.

The last shock analyzed consisted of an increase in the price of the natural resource. The results coincided with common wisdom: GDP, consumption, investment, and wages increased. On the other side, exports of the domestically-produced good fell due to appreciation of the currency. In other words, higher prices of the natural resource generated the well-known Dutch disease. However, the magnitude of the effect was negligible. Indeed, when compared with a rule that keeps the budget always balanced, it is evident that our baseline fiscal rule is strongly countercyclical, saving most of the windfall and avoiding most of the undesired currency appreciation and reduction of exports of the domestically-produced good. In conclusion, the fiscal rule included in our baseline model, which captures the spirit of the Chilean fiscal regime, also has the ability to smooth the cycles due to shocks to the price of the natural resource exported by the small economy, making the case for its adoption in similar commodity-exporting economies very strong.

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6 Appendix: Linearized Model

Consumption and labor supply

$$c_t^o = c_{t+1}^o - (r_t - \pi_{t+1})$$

$$c_t^r = \frac{WN}{PC}((w_t - p_t) - \frac{Y}{C}t_t$$

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

The supply of labor with sticky wages is given by

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

Investment

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

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

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

$$i_t = i_t^o$$

$$k_t = k_t^o$$

Equilibrium domestic market

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

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

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

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

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

Budget constraint for the economy

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

Economy risk premium

$$\widehat{\Phi}_t = \phi b_{t+1}^*$$

Equilibrium import market

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

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

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

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

Production function of intermediate domestic good

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

Parity condition

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

Real interest rate (ex-ante)

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

Domestic market inflation

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

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

Import price inflation

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

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

Relative prices

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

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

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

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

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

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

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

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

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

Cost minimization

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

Total inflation

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

GDP without natural resources (yr_t), which is determined in the short run by aggregate demand.

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

Monetary policy follows a Taylor rule

$$r_t = r + \phi_\pi \pi_t + \phi_{yr} yr_t + u_t^r$$

Fiscal rule

$$\frac{P^G}{P}\frac{G}{Y}\left(p_t^G - p_t\right) + \frac{P^G}{P}g_t = -\left(\left(1+\upsilon_b\right)\left(\frac{r}{1+r}\right) + \mu_x\right)b_t^G + u_t^G$$

Budget constraint

$$
\begin{aligned}
\frac{P^G}{P}\frac{G}{Y}\left(p_t^G - p_t\right) + \frac{P^G}{P}g &= t_t + (1+\upsilon_b)\left(\frac{1}{1+r}\right)b_{t+1}^G - (1+\upsilon_b)b_t^G \\
&\quad + \left(\frac{tau\_cu * P^{cu}Q\_cu}{PY}\right)((s_t - p_t) + p_t^{cu})
\end{aligned}
$$

Taxes

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

Fiscal deficit

$$deficit = g_t - t_t - \left(\frac{tau\_cu * P^{cu}Q\_cu}{PY}\right)((s_t - p_t) + p_t^{cu})$$

Shocks:

Government spending

$$u_t^G = \rho_G u_{t-1}^G + \epsilon_t^G$$

Foreign prices

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

External demand for the domestic good

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

Foreign price of the domestically-produced export

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

International price of natural resource

$$p_t^{cu} = \rho_{cu} p_{t-1}^{cu} + \epsilon_t^{cu}$$

Technology

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

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
Mark-up (intermediate goods) $i = D, F$	$(\frac{\varepsilon_i}{\varepsilon_i - 1})$	1.20
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
Labor Market Mark-up	$1 + \theta_w$	1.20
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 yr (demand determined)	ϕ_{yr}	0.00
Autoregressive coefficient of government expenditure shock	ρ_G	0.90
Autoregressive coefficient of lump-sum taxes shock	ρ_u	0.90
Autoregressive coefficient of copper price	ρ_{cu}	0.70
Weight of domestic good in consumption	α_c	0.70
Weight of domestic good in investment	α_I	0.50
Weight of domestic good in government expenditure	α_G	0.99
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/external debt ratio	$\frac{1}{\upsilon_b} = \frac{B_t^G}{S_t B_t^{G*}}$	0.21
Inverse of work effort elasticity with respect to real wage	φ	0.20

Table 2: Steady State Values

Consumption / output ratio	$\frac{C}{Y}$	0.63
External debt / output ratio	$\frac{B^*}{Y}$	0.50
Investment / output ratio	$\frac{I}{Y}$	0.16
Export / output ratio	$\frac{X}{Y}$	0.34
Import / output ratio	$\frac{Y^F}{Y}$	0.33
Government expending / output ratio	$\frac{G}{Y}$	0.20
N. Resource Production / GDP ratio	$\frac{Q_{cu}}{Y}$	0.08

Table 3: **Impact of a (1%) Shock to the Price of Copper on the RER (%)***

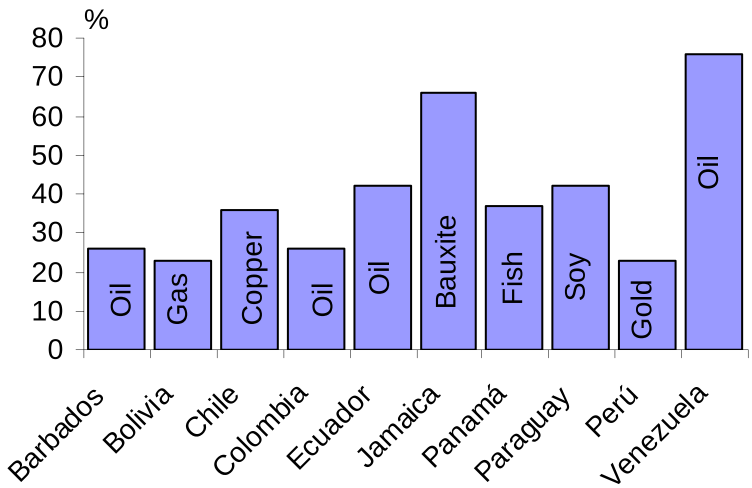
(With different persistence values)

	Structural rule (Cyclically adjusted)	Balanced budget
Temporary shock (rho=0.7)	-0.0133	-0.025
Temporary shock (rho=0.93)	-0.04	-0.09
Temporary shock (rho=0.99)	-0.14	-0.18

*Rho the autocorrelation coefficient between 1973-2005 is 0.93

8 Figures

Figure 1: Main product as share of total exports in 2003



Source: Jiménez and Tromben (2006)

Figure 2: Shock to Government Spending with Different Shares of Rule-of-thumb Consumers

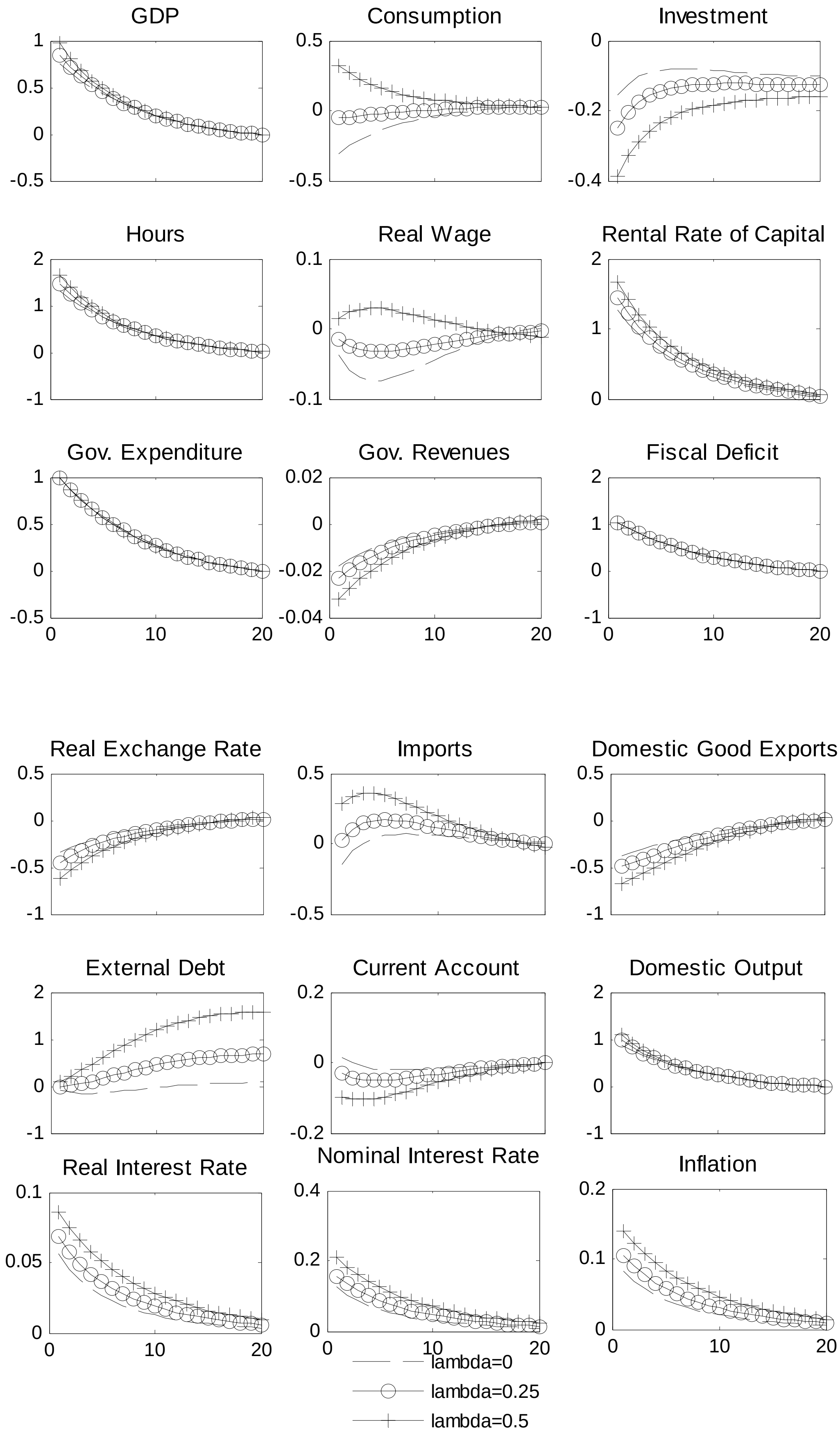


Figure 3: Shock to Government Spending with Different Shares of Domestic Goods in the Government's Consumption Basket

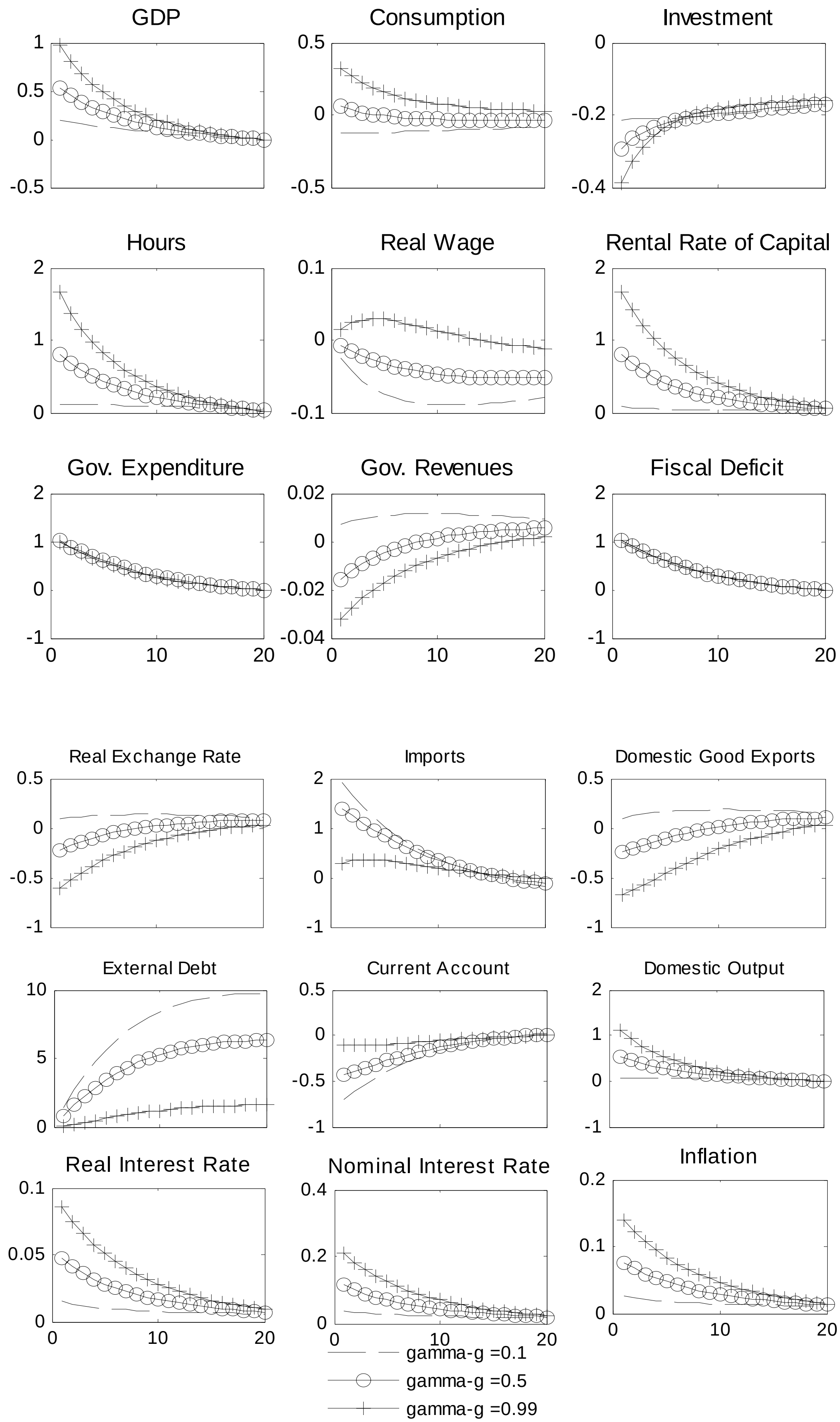


Figure 4: Shock to Taxes with Different Shares of Rule-of-thumb Consumers (λ)

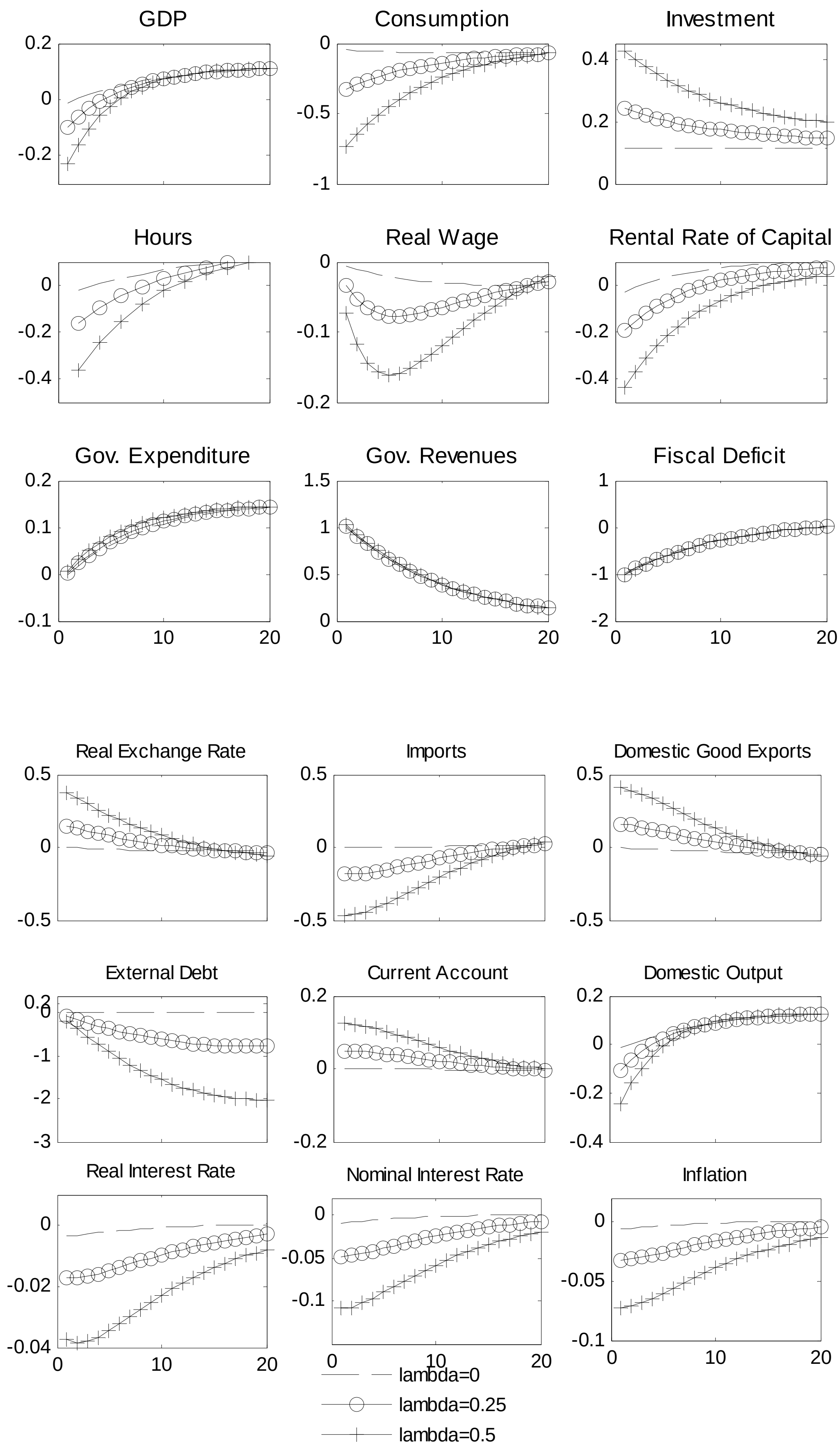


Figure 5: Shock to Taxes with Different Shares of Domestic Goods in the Government's Consumption Basket

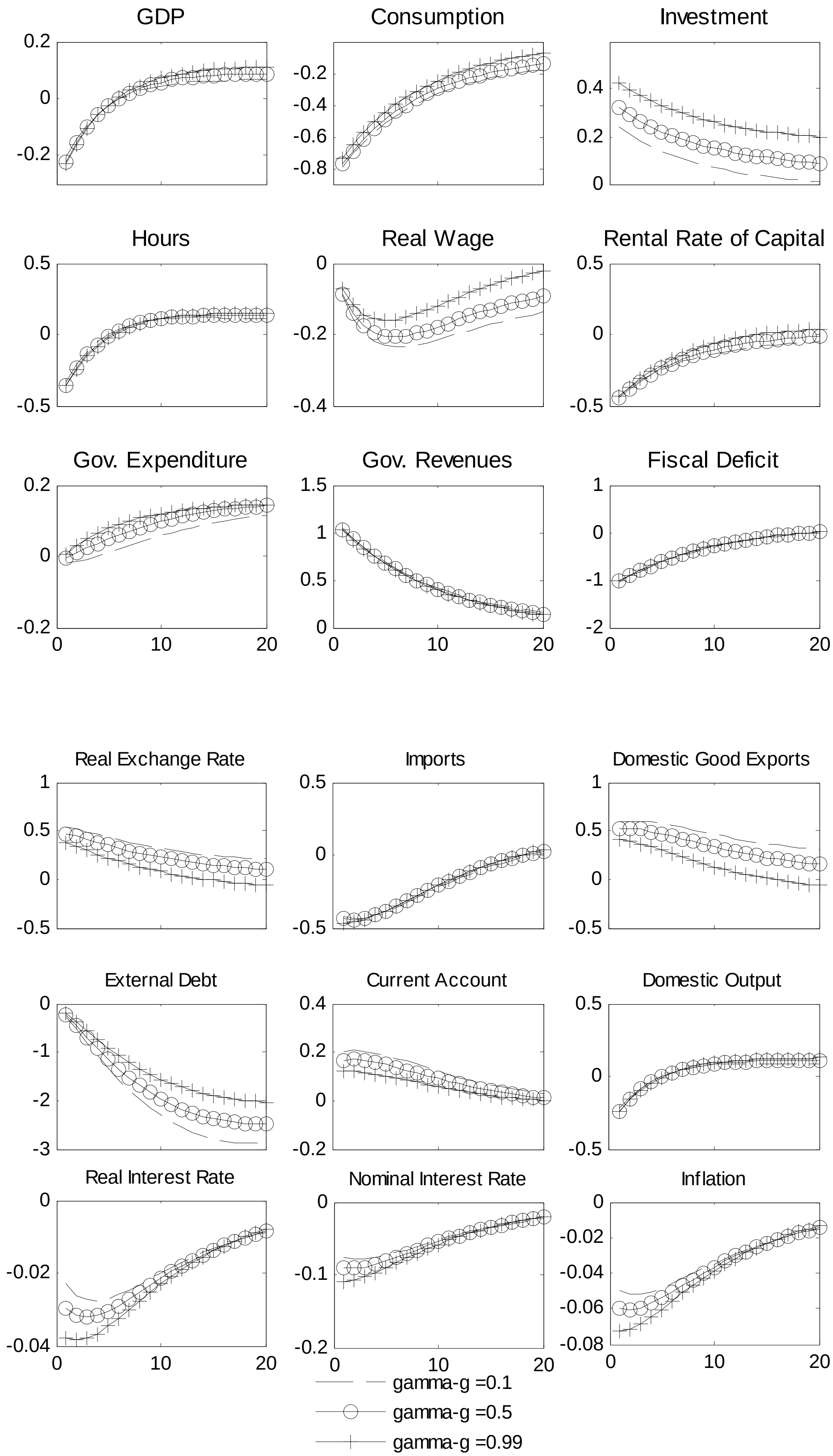


Figure 6: Shock to the Price of the Natural-Resource with Different Shares of its Property

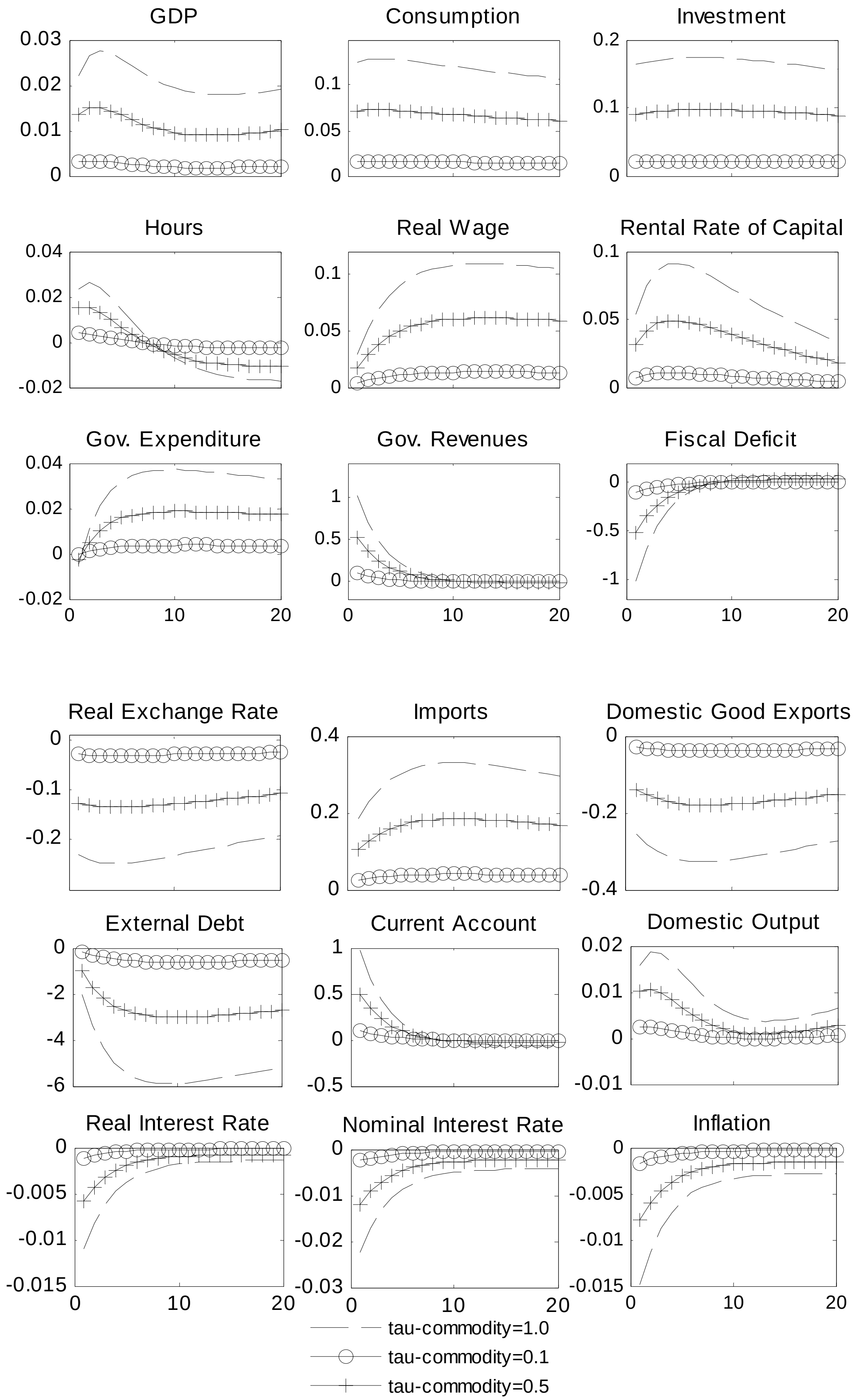


Figure 7: Shock to the Natural Resource Price with two fiscal rules (baseline calibration)

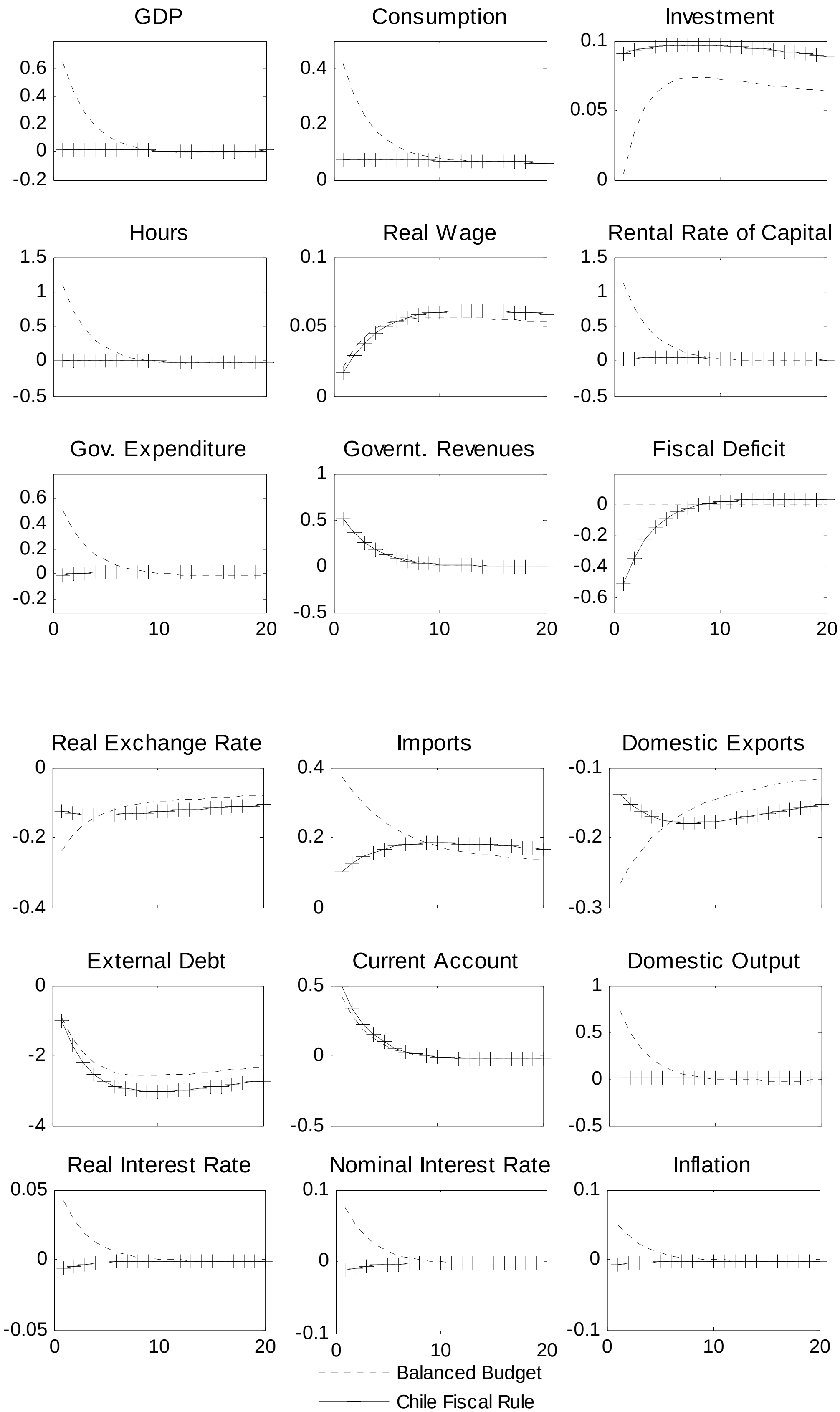


Figure 8: A More Persistent Shock to the Natural Resource Price with Two Fiscal Rules