Universidad de San Andrés
DEPARTAMENTO DE ECONOMÍA

YOUNG RESEARCHERS WORKING PAPER SERIES

FISCAL DOMINANCE, SHOCKS, AND THE CURRENCY DISTRIBUTION OF SOVEREIGN DEBT: THE CASE OF A SMALL OPEN ECONOMY

Juan Pablo Di Iorio (Universidad de San Andrés)

Primera versión: julio 2025
Esta versión: diciembre 2025

Young Researchers Working Paper Nº 19
Departamento de Economía Universidad de San Andrés

Vito Dumas 284, B1644BID, Victoria,
San Fernando, Buenos Aires, Argentina
Teléfono 7078-0400
Email: economia@udesa.edu.ar

Fiscal dominance, shocks, and the currency distribution of sovereign debt: the case of a small open economy*

Juan Pablo Di Iorio

Abstract

This study examines the effects of incorporating fiscal dominance, based on the Fiscal Theory of the Price Level, into a New Keynesian Small Open Economy (NK-SOE) model. This framework enables a comparison between the responses of an economy characterized by fiscal dominance and those of canonical NK-SOE models when faced with monetary or external shocks. Notable differences emerge in nominal variables, such as inflation rates and nominal devaluation, as well as in household consumption and the real exchange rate. I show that introducing fiscal dominance into an otherwise standard NK-SOE model can help explain two important puzzles in the literature: the "price puzzle" and the "exchange rate response puzzle." Furthermore, the model is expanded to account for government debt issued in foreign currency, introducing a fiscal channel related to the currency composition of the government's debt. Additionally, the structure of taxes and government expenditures—particularly fiscal revenues tied to the non-tradable sector—plays a significant role in shaping the economic response when the government issues debt in foreign currency.

JEL Codes: E31, E43, E62, F31

*I would like to thank my advisor, Javier García-Cicco, for his outstanding and invaluable mentorship and support. I am also deeply grateful to Francisco Ciocchini and Francisco Roldán for their insightful comments and feedback. All remaining errors are my own.

1 Introduction

In recent decades, institutional arrangements ensuring central bank independence have strengthened and gained prominence in public discourse. As a result, political cycles and fiscal needs now exert less influence on monetary policy (Romelli, 2024). However, despite this progress, fiscal dominance remains a challenge in several countries, particularly in developing economies.

Early literature on fiscal dominance focused on its most direct mechanism: monetary financing of fiscal deficits, with the work of Sargent & Wallace (1981) being pioneering in this field. Recently, Hazell & Hobler (2024) provide empirical evidence on the relationship between fiscal deficit and inflation. More recent literature has emerged examining an alternative mechanism: the use of inflation to reduce real debt burdens as a means of restoring fiscal solvency. The Fiscal Theory of the Price Level (FTPL) has extensively analyzed this mechanism, though primarily in the context of large and/or closed economies. My work is the first to extend the FTPL framework to small open economies (SOE). This contribution is particularly relevant given that, as shown in Figure 1,[1] central bank independence does not correlate with the size of economies, making the FTPL framework also pertinent for small open economies:

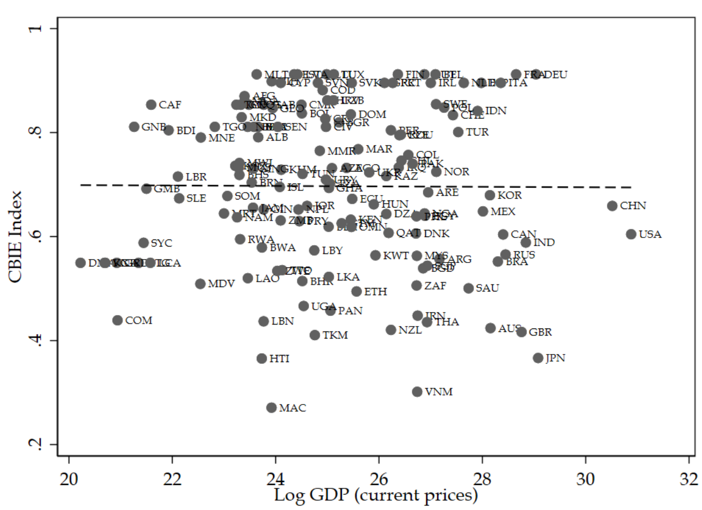

Figure 1: Data on the horizontal axis correspond to the natural logarithm of GDP (in current prices) for the year 2022; data on the vertical axis correspond to the value of the Central Bank Independence - Extended (CBIE) index for the year 2022, developed in Romelli (2022).

[1] GDP in current prices was measured in 2022 using data from the World Bank database, and the Central Bank Independence - Extended (CBIE) index was obtained from Romelli (2024).

Moreover, a growing number of developing countries have shifted towards issuing debt in domestic currency, with a substantial share of recent government securities denominated in local currency at fixed interest rates (Jiang, 2022). More specifically, Ottonello & Perez (2019) claim that during the previous decade, the average share of debt in local currency for a panel of 18 emerging economies increased from 10 percent to 39 percent. This departure from the phenomenon commonly referred to as "original sin" highlights the increasing relevance of integrating the Fiscal Theory of the Price Level (FTPL) framework into models of small open economies. This framework builds on early work of Leeper (1991), Sims (1994) and Woodford (1995).

Based on these recent trends, this paper seeks to address the gap in the literature of the Fiscal Theory of the Price Level by its inclusion in traditional New Keynesian Small Open Economy models to contrast predictions with models of closed economies, as well as exploring the evolution of variables that had not been previously investigated, such as the real exchange rate and the nominal exchange rate, and the response of these economies to external shocks. In this sense, I will show that integrating the FTPL into a NK-SOE model can help explain two major puzzles in the literature: the "price puzzle" and the "exchange rate response puzzle."

First, I develop a canonical New Keynesian Small Open Economy (NK-SOE) model with sticky prices à la Calvo, active fiscal policy, where the government issues debt exclusively in domestic currency. Within this framework, I find that incorporating the Fiscal Theory of the Price Level (FTPL) into such models yields results that diverge from traditional SOE models: following a contractionary monetary shock, the nominal exchange rate appreciates only on impact but subsequently reverses, even depreciating. This result is consistent with previous empirical literature for emerging economies (Hnatkovskay et al., 2012; Kohlscheen, 2014).

Moreover, I introduce two types of active fiscal policy: (i) lump-sum transfers to households fixed in real terms and a labor income tax on non-tradable workers; (ii) lump-sum taxes fixed in real terms. This heterogeneity allows me to explore differences in the model's endogenous variables depending on the government's fiscal policy. In the context of a contractionary monetary shock, the model reveals distinct inflation dynamics: with labor income tax, the inflation pattern aligns with what Sims (2011) calls "Stepping on a rake"—an initial disinflation followed by an increase above the steady-state value—whereas in the model without labor income tax, inflation increases at impact.

Additionally, by assuming different Taylor Rules, I explore the differences in the reaction to external shocks of an economy characterized by the FTPL compared to canonical NK-SOE models. In particular, I find that, following a negative shock to the endowment of tradable goods, the model with fiscal dominance exhibits a larger real depreciation along with a less negative or even positive reaction from consumption, particularly of non-tradable goods.

Finally, I allow the government to issue debt in both domestic and foreign currency. In this context, by exploring various rules regarding the share of each type of currency chosen by the government, I examine the reaction of economies to different shocks under varying distributions of sovereign debt. First, I find that whether the government collects revenue from the non-tradable sector or not can lead to entirely different dynamics in the real exchange rate when the government issues only foreign currency-denominated debt: with a labor income tax, an expansionary fiscal policy generates a real depreciation, similar to the model with domestic currency debt. However, in the model without a labor income tax, this result is reversed: the real exchange rate must appreciate in order to reestablish the FTPL equilibrium condition.

In addition, I find that following a contractionary monetary shock, inflation is higher in the model where the government issues only domestic currency debt, whereas in the model where it issues only foreign currency debt, the real exchange rate remains consistently more appreciated than in the previous case. Both results reflect the different mechanisms for restoring the real value of debt in each model. Regarding external shocks, the role of the non-tradable sector is critical when dealing with shocks that depreciate the real exchange rate: when the government issues debt only in foreign currency, a larger real depreciation and a higher inflation rate (and thus a lower discount rate) are required to increase the present value of labor income tax revenues.

Although early research has explored the impact of the Fiscal Theory of the Price Level (FTPL) in open economies across various dimensions—such as its implications for currency crises in economies with pegged exchange rates (Daniel, 2001; Daniel, 2010) and as an explanation for cross-country variations in currency risk premia (Jiang, 2022)— no one has systematically integrated the FTPL framework into a model that includes price rigidities, as well as tradable and non-tradable sectors, within the context of a small open economy. More specifically, the work of Jiang (2022) is the most closely related; however, it focuses on a two-country model and does not account for the possibility of the government issuing foreign currency debt.

2 Model

This section presents a canonical New-Keynesian Small Open Economy (NK-SOE) model with sticky prices à la Calvo and introduces a novel feature: the inclusion of an active fiscal policy. Specifically, the model incorporates the standard equilibrium condition found in the Fiscal Theory of the Price Level literature, where the real value of nominal debt equals the present value of future surpluses.

2.1 Households

The small open economy is inhabited by a continuum of identical, infinitely lived agents with defined preferences over Consumption (c_{it}) and Work (h_{it}), who seek to maximize the following utility function:

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left[\frac{c_{it}^{1-\sigma}}{1-\sigma} - \frac{h_{it}^{1+\phi}}{1+\phi} \right] \right] \tag{1}$$

where $\beta \in (0,1)$ is the subjective discount factor, $\mathbb{E}_t$ the mathematical expectations operator conditional upon information available in period t and c_{it} is a composite consumption index defined by:

$$c_{it} = \left[(1-\omega)^{\frac{1}{\eta}} (c_{it}^T)^{\frac{\eta-1}{\eta}} + \omega^{\frac{1}{\eta}} (c_{it}^N)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{2}$$

where c_{it}^T represents the consumption of tradable goods and c_{it}^N the consumption of non tradable goods.

Households' maximization problem is subject to the sequential budget constraint given by:

$$\frac{B_{it}^{H}}{1+i_t} + E_t \frac{B_{it}^{*H}}{1+i_t^*} + P_t^T c_{it}^T + P_t^N c_{it}^N \leq P_t^T y_{it}^T + (1-\tau) W_t h_{it} + P_t \Phi_{it} + T_{it} + B_{it-1}^{H} + E_t B_{it-1}^{*H}$$

which states that each agent allocates their tradable endowment (y_{it}^T), labor income ($W_t h_{it}$) net from tax rate (τ), dividends from firms which they hold ownership (Φ_{it}), lump-sum transfers received from the government (T_{it}) and their holdings of domestic currency (B_{it-1}^H) and foreign currency (B_{it-1}^{*H}) bonds to the consumption of tradable and non tradable goods, as well as the issuance of new bonds. E_t denotes the nominal exchange rate, i_t the interest rate of domestic currency bonds, i_t^* the interest rate of foreign currency bonds, P_t^N the nominal price of nontraded goods and P_t^T the nominal price of tradable goods. Bonds are one-period and state non-contingent.

In line with the two-stage budgeting approach (Strotz 1957; Gorman 1959), the optimal allocation of expenditure yields the following demand for each type of good:

$$c_{it}^T = (1-\omega) \left(\frac{P_t^T}{P_t} \right)^{-\eta} c_{it} \tag{3}$$

$$c_{it}^N = \omega \left(\frac{P_t^N}{P_t} \right)^{-\eta} c_{it} \tag{4}$$

which implies that the price level equals: $P_t = \left[(1-\omega)(P_t^T)^{1-\eta} + \omega (P_t^N)^{1-\eta} \right]^{\frac{1}{1-\eta}}$

Using the fact that $P_t c_{it} = P_t^T c_{it}^T + P_t^N c_{it}^N$, the budget constraint could be restated relative to the price level:

$$\frac{b_{it}^{H}}{1+i_t} + rer_t \frac{b_{it}^{*H}}{1+i_t^*} + c_{it} \leq p_t^T y_{it}^T + (1-\tau) w_t h_{it} + \Phi_{it} + t_{it} + \frac{b_{it-1}^{H}}{1+\pi_t} + rer_t \frac{b_{it-1}^{*H}}{1+\pi_t^*} \tag{5}$$

where rer_t is the real exchange rate, p_t^T is the relative price of tradables to the price level, π_t is the domestic inflation rate, π_t^* is the foreign inflation rate and w_t the real wage.

Thus, the optimization problem of each household i is defined by the maximization of (1) subject to (5). Then the remaining optimality conditions for the household's problem are:

$$\lambda_t = c_{it}^{-\sigma}$$

$$\lambda_t(1-\tau)w_t = h_{it}^{\phi}$$

$$\lambda_t = \beta(1+i_t^*)\mathbb{E}_t\left[\frac{\lambda_{t+1}(1+\varepsilon_{t+1})}{(1+\pi_{t+1})}\right]$$

$$\lambda_t = \beta(1+i_t)\mathbb{E}_t\left[\frac{\lambda_{t+1}}{(1+\pi_{t+1})}\right]$$

where $1+\varepsilon_t \equiv \frac{E_t}{E_{t-1}}$

2.2 Firms - Non Tradable Sector

Following Calvo (1983), it will be assumed that there are time-dependent sticky prices but, in this case, the rigidity will originate from the producers of intermediate goods who supply inputs to the producers of the final nontraded good.[2]

2.2.1 Final Good

Final good producers will be assumed to operate in a competitive market. Regarding the production function, the final good is produced with a continuum of differentiated input varieties of measure one:

$$\max_{<y_t^N, a_{jt}^N>} \Pi_t^N = P_t^N y_t^N - \int_0^1 P_{jt}^N a_{jt}^N \partial i \qquad s.t.: \qquad y_t^N = \left[\int_0^1 (a_{jt}^N)^{1-\frac{1}{\mu}} \partial i\right]^{\frac{1}{1-\frac{1}{\mu}}}$$

where a_{jt}^N denotes the demand of intermediate good j for the production of the final nontraded good and P_{jt}^N denotes the nominal price of variety j in period t. From the first order conditions associated to this optimization problem it can be derived the following optimal demand for variety j:

$$a_{jt}^N = y_t^N \left(\frac{P_{jt}^N}{P_t^N}\right)^{-\mu}$$

[2]For a similar framework, see Uribe and Schmitt-Grohé (2017)

Thus, the final price of nontraded goods can be reexpressed in the following way:

$$P_t^N = \left[\int_0^1 \left(P_{jt}^N\right)^{1-\mu} \partial j\right]^{\frac{1}{1-\mu}} \tag{6}$$

2.2.2 Intermediate Goods

Nontraded intermediate goods are assume to operate in a monopolistically competitive market (Dixit and Stiglitz, 1977) where each firm in the interval $[0, 1]$ produce a differentiated variety with a production technology given by:

$$y_{jt}^N = h_{jt}^\alpha \tag{7}$$

In addition, it will be impose Calvo price rigidities. That is, firms have a probability of $1-\theta$ of being able to re-optimize their price and a probability of θ of having to maintain the price from the previous period. In this way, when the firm chooses the optimal price to set, it must take into account that there is a non-zero probability (this would be the case of price flexibility) that in subsequent periods it will have to maintain the price chosen at that moment. Consequently, the optimization problem that producers of intermediate goods face can be represented by:

$$\max_{<\tilde{P}_{jt}^N>} VP\Pi_{jt} = \mathbb{E}_t \sum_{s=0}^{\infty} \eta_{t,t+s}\theta^s \left[\tilde{P}_{jt}^N y_{t+s}^N \left(\frac{\tilde{P}_{jt}^N}{P_{t+s}^N}\right)^{-\mu} - W_{t+s} {y_{t+s}^N}^{\frac{1}{\alpha}} \left(\frac{\tilde{P}_{jt}^N}{P_{t+s}^N}\right)^{-\frac{\mu}{\alpha}}\right]$$

where $\eta_{t,t+s}$ denotes the state-contingent nominal discount factor of firms and $\tilde{P}_{jt}^N$ the optimal nominal price chosen by intermediate goods producers. The associated first order condition is:

$$\mathbb{E}_t \sum_{s=0}^{\infty} \eta_{t,t+s}\theta^s y_{t+s}^N \left(\frac{\tilde{P}_{jt}^N}{P_{t+s}^N}\right)^{-\mu} \left[\frac{\mu-1}{\mu} P_{jt}^N - \frac{1}{\alpha} W_{t+s} \left[y_{t+s}^N \left(\frac{\tilde{P}_{jt}^N}{P_{t+s}^N}\right)^{-\mu}\right]^{\frac{1-\alpha}{\alpha}}\right] = 0 \tag{8}$$

2.3 Government

The fiscal authority independently defines a sequence of $\{t_t, \tau\}$ such that the real value of the primary surplus in period t is given by:

$$s_t = \tau w_t h_t - t_t$$

Public expenditure is fixed in real terms, and taxes are a function of labor income. As a result, government solvency is not guaranteed for every path of the price level, which is in line with what Leeper (1991) defines as an active fiscal policy[3]. In this initial simplified version[4], the government only can issue nominal debt in domestic currency. Thus, the government's flow budget constraint is:

$$\frac{B_{t-1}}{P_t} = s_t + \frac{b_t}{1+i_t}$$

As it is mentioned before, this equations turns to be an equilibrium condition, which is satisfied only for a determined (and unique) price level. Regarding the monetary authority, I will first assume that the interest rate follows an exogenous process. It is important to note that the implementation of an active fiscal policy ensures the local uniqueness of equilibrium in a New Keynesian Small Open Economy with an exogenous interest rate (i.e. not active monetary rule).

2.4 External sector

Given the dependence of the steady state on initial conditions in Small Open Economy models, as well as the random-walk behavior exhibited by equilibrium dynamics, it will be assumed that the interest rate on foreign currency debt is a decreasing function of net foreign assets in order to

[3] This is a particular extreme case of active fiscal policy in which taxes do not respond to the level of real government debt outstanding.

[4] In Section 4, the model is extended to allow the government to issue debt in foreign currency.

induce stationarity (Schmitt-Grohé and Uribe, 2003).[5] [6]

$$1 + i_t^* = 1 + i_t^W + \psi(e^{(\overline{b^{*H}} - b_t^{*H})} - 1)$$

where i_t^W is then international risk-free rate.

2.5 Aggregation and equilibrium

Since the unit mass of households are identical, in equilibrium:

$$\begin{aligned}
c_t &= c_{it} \\
c_t^T &= c_{it}^T \\
c_t^N &= c_{it}^N \\
h_t &= h_{it} \\
b_t^H &= b_{it}^H \\
b_t^{*H} &= b_{it}^{*H} \\
\Phi_t &= \Phi_{it}
\end{aligned}$$

Since it is assumed that firms are owned by households, in equilibrium it must hold that:

$$\eta_{t,t+s} = \beta^s \frac{\lambda_{t+s}}{\lambda_t} \frac{P_t}{P_{t+s}}$$

Given that intermediate goods producers are homogeneous[7], the optimal price ($\tilde{P}_{jt}$) is equal for all firms. Furthermore, since there is a continuum of intermediate goods producers with a measure of one, by the law of large numbers, equation (6) can be re-expressed as:

$$\left(P_t^N\right)^{1-\mu} = \theta(P_{t-1}^N)^{1-\mu} + (1-\theta)(\tilde{P}_t^N)^{1-\mu}$$

[5] Inversely to Schmitt-Grohé and Uribe (2003), in this model bonds are assumed to be an asset rather than debt.

[6] See also Senhadji (1994), Mendoza and Uribe (2000), and Schmitt-Grohé and Uribe (2001).

[7] Except for the timing at which each firm can reoptimize its price.

Following Uribe and Schmitt-Grohé (2017), the optimality condition of intermediate goods producers could be split into two parts: the present discounted value of marginal revenue and the present discounted value of marginal cost.

$$pvmc_t = \frac{1}{\alpha}\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \frac{\lambda_{t+s}}{\lambda_t} \theta^s y_{t+s}^N \left(\tilde{p}_t^N \prod_{k=1}^{s} \frac{1}{1+\pi_{t+k}^N} \right)^{-\mu} w_{t+s} \left[y_{t+s}^N \left(\tilde{p}_t^N \prod_{k=1}^{s} \frac{1}{1+\pi_{t+k}^N} \right)^{-\mu} \right]^{\frac{1-\alpha}{\alpha}}$$

$$pvmr_t = \frac{\mu-1}{\mu}\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \frac{\lambda_{t+s}}{\lambda_t} \theta^s y_{t+s}^N \left(\tilde{p}_t^N \prod_{k=1}^{s} \frac{1}{1+\pi_{t+k}^N} \right)^{1-\mu} p_{t+s}^N$$

Which can be re-expressed recursively:

$$pvmc_t = \frac{1}{\alpha}\left(y_t^N\right)^{\frac{1}{\alpha}} w_t \left(\tilde{p}_t^N\right)^{-\frac{\mu}{\alpha}} + \theta\beta\mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{\tilde{p}_t^N}{\tilde{p}_{t+1}^N} \frac{1}{1+\pi_{t+1}^N} \right)^{-\frac{\mu}{\alpha}} pvmc_{t+1} \tag{9}$$

$$pvmr_t = \frac{\mu-1}{\mu} y_t^N p_t^N \left(\tilde{p}_t^N\right)^{1-\mu} + \theta\beta\mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{\tilde{p}_t^N}{\tilde{p}_{t+1}^N} \frac{1}{1+\pi_{t+1}^N} \right)^{1-\mu} pvmr_{t+1} \tag{10}$$

$$pvmc_t = pvmr_t \tag{11}$$

where $\tilde{p}_t^N$ is the relative price of optimum price in terms of the final non-tradable good and π_{t+1}^N is the inflation rate of nontradables.

Market clearing in the labor market implies that:

$$h_t = \int_0^1 h_{jt} \partial j$$

Using this condition in 7 gives:

$$y_t^N = \chi_t^{-\alpha} h_t^{\alpha} \tag{12}$$

where

$$\chi_t = \theta \chi_{t-1}(1+\pi_t^N)^{\frac{\mu}{\alpha}} + (1-\theta)\left(\tilde{p}_t^N\right)^{-\frac{\mu}{\alpha}} \tag{13}$$

Finally, by iterating the government's sequential budget constraint, the traditional FTPL equation can be derived:

$$\frac{b_{t-1}}{1+\pi_t} = \mathbb{E}_t\left[\sum_{i=0}^{\infty} \beta^i \frac{\lambda_{t+i}}{\lambda_t} s_{t+i}\right]$$

Which can be re-expressed recursively:

$$pvs_t = \tau w_t h_t - t_t + \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} pvs_{t+1} \tag{14}$$

$$\frac{b_{t-1}}{1+\pi_t} = pvs_t \tag{15}$$

Where pvs_t represents the present value of fiscal surpluses.

Note that, in equilibrium, the market clearing condition implies that:

$$b_t = b_t^H$$

Definition 1 (Competitive Equilibrium): A *competitive equilibrium* is a set of processes $\lambda_t, c_t, w_t, h_t, i_t^*, \varepsilon_t, \pi_t, b_t^H, rer_t, b_t^{*H}, c_t^T, c_t^N, p_t^T, p_t^N, \pi_t^N, \tilde{p}_t^N, b_t, pvs_t, pvmc_t, pvmr_t, y_t^N$ and χ_t satisfying conditions (E.1)−(E.22)[8] and given stochastic processes for the exogenous disturbances $i_t, i_t^W, y_t^T, \pi_t^*$ and t_t.

[8] The equilibrium conditions are found in Appendix I

2.6 Calibration and equilibrium dynamics

Exogenous driving forces are modeled as autoregressive processes given by:

$$log(x_t) = \alpha_x log(x_{t-1}) + (1 - \alpha_x) log(\overline{x}) + e_t^x$$

where $x = \{1+i_t, 1+i_t^W, y_t^T, 1+\pi_t^*\}$, $\overline{x}$ the steady state value of exogenous variables and e_t^x are i.i.d. shocks (independent and identically distributed). Regarding parameters, the model is calibrated with standard values of the literature (Uribe and Schmitt-Grohé, 2017; Galí and Monacelli, 2005) of New Keynesian and Small Open Economies:

Table 1: Parameter Values

Parameter	Value	Description
σ	2	Inverse of intertemporal elasticity of substitution
τ	0.16/0	Tax rate on labor income
ϕ	3	Inverse of labour supply elasticity
β	$(1.0316)^{-\frac{1}{4}}$	Subjective discount factor
ω	0.6	Share of non-tradables
η	$1/\sigma$	Intratemporal elasticity of substitution
θ	0.7	Probability of no re-optimizing price in non-tradables
μ	6	Elasticity of substitution across intermediate varieties
α	0.75	Labor share in nontraded sector
ψ	0.0000335	Parameter of debt-elastic interest rate

Note: Variables are in quarterly frequency

The introduction of a labor income tax aims to add a potential amplifying effect or limit inflation by affecting the present value of fiscal surpluses in response to a shock. To assess this potential effect, two alternatives will be explored: one with a tax rate of 0.16 and, alternatively, one in which the tax rate is 0, with tax revenue collected through lump-sum taxes. Lump-sum transfers/taxes are calibrated so that both cases present the same fiscal surplus in the steady state.

Figure 2 shows the response of the main endogenous variables to an increase in the domestic interest rate. As it may be seen, the behavior of inflation in a small open economy with price rigidities and a labor income tax is similar to what Sims (2011)[9] calls "Stepping on a rake". This

[9]Cochrane (2018) shows that a similar pattern appears when long-term debt is introduced to standard FTPL models.

phenomenon suggests that monetary tightening may initially lead to a decline in inflation and a recession through traditional channels. However, over the long run, the “Fisherian principle” stands: a persistent increase in the nominal interest rate eventually causes inflation to rise above its steady-state level. The interpretation of this feature is similar to Sargent & Wallace (1981) (though the mechanisms differ): monetary contraction without fiscal support (i.e. no reaction of surpluses) can only temporarily control inflation. This feature contrasts with traditional New-Keynesian models where an interest rate hike provokes a disinflation that monotonically converges to the steady state.

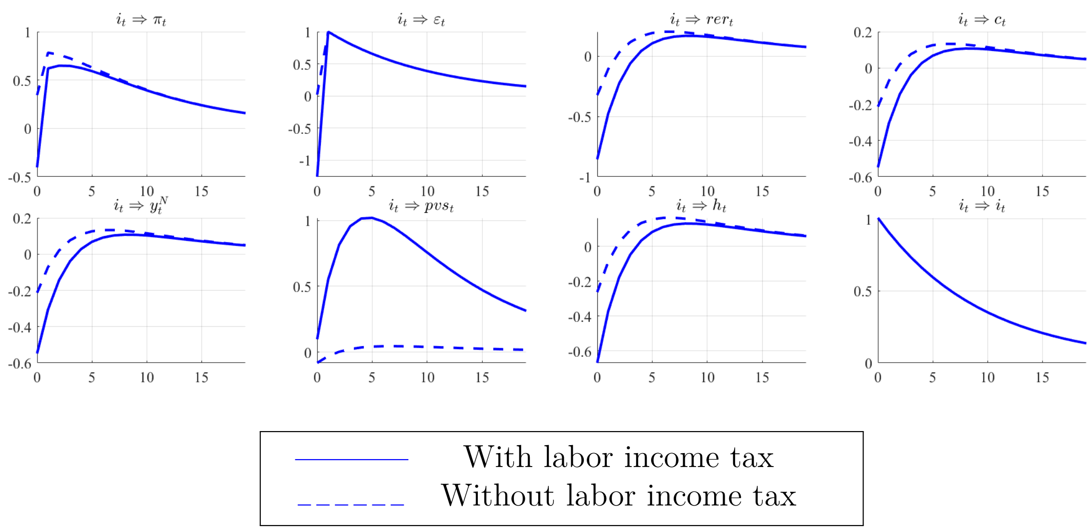

Figure 2: Impulse-response functions for inflation, exchange rate depreciation, real exchange rate, consumption, non-tradable output, wages, and hours worked to a one standard deviation positive shock to the domestic interest rate.

Furthermore, the model without a labor income tax (and hence without reaction of tax collection to shocks) does not exhibit initial disinflation; instead, there is an initial upward jump in the inflation rate, which remains higher until it converges with the model that includes a labor income tax. This model characteristic supports the hypothesis that the labor income tax helps contain inflation rather than amplifying it, as it enhances the present value of fiscal surpluses by partially offsetting the negative impact of the interest rate hike through the increased present value of labor income tax revenue.

Additionally, a novel feature of this model is the possibility to observe how the real exchange rate (rer) reacts to an interest rate hike in an FTPL model. Although the initial reaction of the real exchange rate is qualitatively similar to what is found in the literature on SOE models, following the initial currency appreciation, the effect reverses, ultimately driving the real exchange rate above its steady-state value. In this sense, the dynamic of the nominal exchange rate depreciation provides a suitable explanation for a fact that Hnatkovskay, Lahiriy, and Vegh (2012) call "The exchange rate response puzzle": in developing countries, exchange rates tend to depreciate following an interest rate hike rather than appreciate, which is the prediction of standard small open economy models.

The departure of this model from standard SOE models in this particular feature could be interpreted through the lens of the UIP condition. Using equilibrium conditions (E.3) and (E.4), and the property of the expected value of a product:

$$\frac{1+i_t}{1+i_t^*} = \mathbb{E}_t\left[1+\varepsilon_{t+1}\right] + \frac{COV_t\left[1+\varepsilon_{t+1}, \iota_{t,t+1}\right]}{\mathbb{E}_t\left[\iota_{t,t+1}\right]}$$

where $\iota_{t,t+i} \equiv \beta^h \frac{\lambda_{t+i}}{\lambda_t}\frac{P_t}{P_{t+i}}$

Applying a log-linear approximation:

$$\hat{i}_t - \hat{i}_t^* = \mathbb{E}_t\left[\hat{\varepsilon}_{t+1}\right] \;\Rightarrow\; \hat{E}_t = \hat{i}_t^* - \hat{i}_t + \mathbb{E}_t\left[\hat{E}_{t+1}\right]$$

Iterating forward and using the definition of rer_t:

$$\hat{E}_t = \sum_{i=0}^{\infty}\mathbb{E}_t\left[\hat{i}_{t+i}^* - \hat{i}_{t+i}\right] + \sum_{i=0}^{\infty}\mathbb{E}_t\left[\hat{\pi}_{t+i} - \hat{\pi}_{t+i}^*\right]$$

where in a stationary equilibrium:

$$\lim_{i\to\infty}\mathbb{E}_t\left\{r\hat{e}r_{t+1+i}\right\} = 0$$

This equation shows that deviations in the nominal exchange rate depend negatively on interest rate differentials and positively on inflation rate differentials. In this model, an initial interest rate differential arises following a domestic interest rate shock, gradually diminishing as seen in standard small open economy (SOE) models. However, unlike traditional models, this model uniquely features a rise in the inflation rate (and thus in the inflation rate differential) following contractionary monetary policy. This feature supports the idea of fiscal dominance as a potential explanation for nominal depreciations following domestic interest rate hikes in developing countries.[10]

This model also allows me to explore the effect of an exogenous expansionary fiscal policy. Particularly, Figure 3 plots the response of the main endogenous variables to a increase (decrease) in the lump-sum transfers (taxes) for the model with (without) labor income tax:

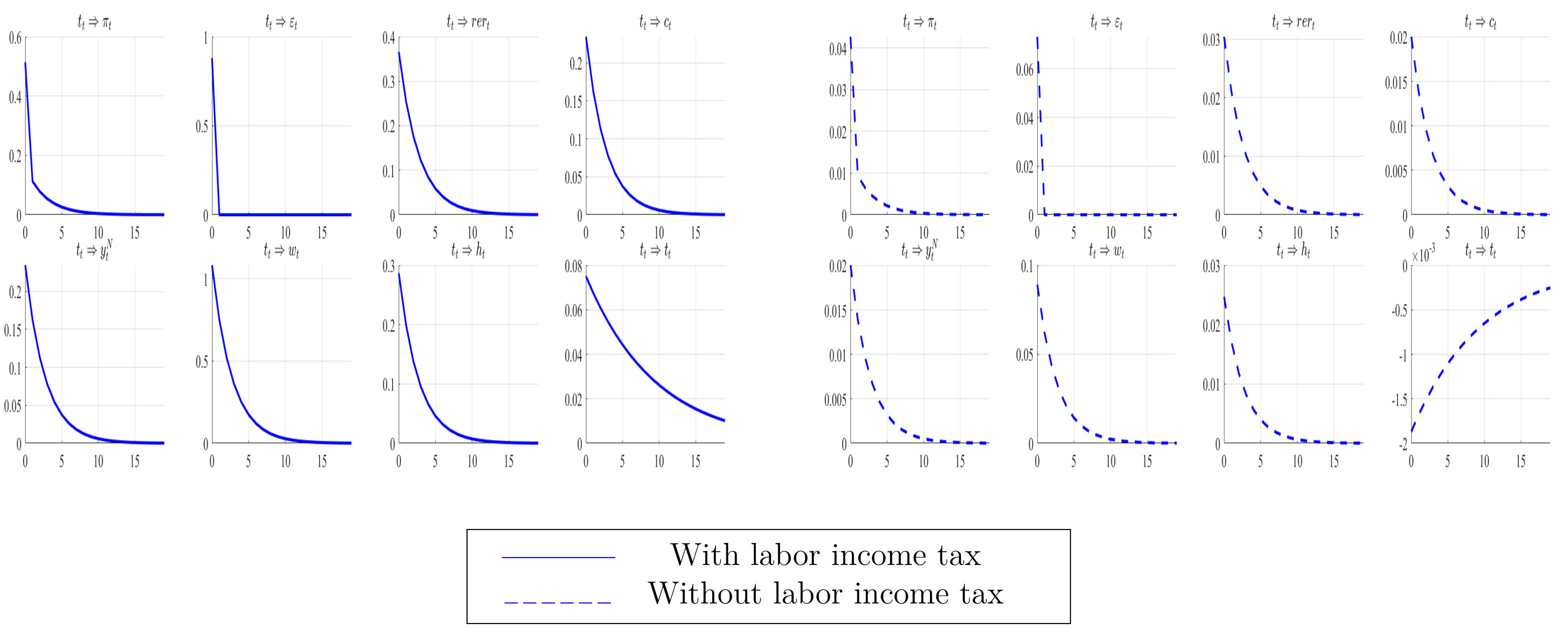

Figure 3: Impulse-response functions for inflation, exchange rate depreciation, the present value of fiscal surpluses, real exchange rate, consumption, non-tradable output, wages, and hours worked to a one standard deviation expansionary fiscal shock.

As expected, the fiscal shock triggers an instantaneous rise in the inflation rate, accompanied by an even larger surge in the growth rate of the nominal exchange rate, which consequently leads to a real depreciation. This model feature is consistent with the findings of Jiang (2018) for a sample of 25 countries.

In contrast to a Ricardian response from households that would arise in a model with passive fiscal policy, the fiscal shock has a positive effect on consumption, driven by an increase in non-tradable consumption. This effect arises partly from higher expenditure on non-tradable goods,

[10] Hnatkovskay, Lahiriy, and Vegh (2012) and Kohlscheen (2014) provide empirical evidence.

as the real depreciation makes these goods relatively cheaper. Notably, under the assumption of an exogenous stochastic process for the interest rate, the nominal interest rate does not adjust upward in response to the inflation surge, with the intertemporal channel being the main factor behind the positive consumption response.

The unfunded fiscal shock is the reason behind the increase in inflation, as it works to reestablish the "fiscal intertemporal equilibrium condition" by inflating away nominal debt. As a result, a sharp decline in the real value of debt occurs initially, though this effect diminishes over time due to the temporary, yet moderately persistent, nature of the fiscal shock. Simultaneously, the rise in non-tradable output —and the corresponding increase in hours worked— boosts labor income tax revenues, which partially offset the decline in the present value of fiscal surpluses caused by the shock.

In the next section, the response of this economy to shocks will be compared to that of an economy without fiscal dominance by assuming monetary or exchange rate rules.

3 Comparing regimes

In this section, the response of an economy with an active fiscal policy is compared to one with a passive fiscal policy in the face of monetary and external shocks. The purpose of this section is to determine whether the model's endogenous variables react differently to monetary and external shocks (primarily to domestic and international interest rate, and tradable goods output shocks) depending on the fiscal-monetary regime in place. For this analysis, two types of policy rules will be considered: a Taylor rule and a fixed exchange rate regime.

In contrast with the active fiscal policy, the passive fiscal policy regime ensures that government solvency is satisfied independently of the path of the price level. In this sense, the sequence of lump-sum transfers from government (T_t) are defined endogenously to satisfy the budget constraint at any price level. This assumption is what is implied in traditional NK-SOE models.

3.1 Taylor rule

Firstly, it is assumed that the interest rate does not follow an autoregressive process (AR(1)), but rather follows a monetary policy rule of the 'Taylor Rule' type:

$$\frac{1+i_t}{1+\bar{i}} = \left(\frac{1+\pi_t}{1+\overline{\pi}}\right)^{\alpha_\pi} \epsilon_t^i \tag{16}$$

where $\{\bar{i}, \overline{\pi}\}$ denotes the steady state value of each variable.

It is important to notice that the "Taylor Principle" states that α_π must be greater than 1 in order to ensure the *uniqueness* of equilibrium. However, in the case of an active fiscal policy this condition is reverse (Leeper, 1991).

In order to compare the response to shocks under each type of regime, two values will be assumed for α_π in each model: 0.80 (standard value in the FTPL literature) and 0.99 for the fiscal dominance model, and 1.50 (standard value in the literature) and 1.01 for the monetary dominance model. In this sense, the values of 0.99 and 1.01 are chosen to minimize differences in the economies' responses that could be attributed to varying interest rate reactions to deviations in the inflation rate.

3.1.1 Monetary shock

The reaction of both types of regimes to a 1 p.p. hike in the interest rate is contrasted in Figure 4. Although both models—monetary dominance and fiscal dominance—exhibit a decline in the inflation rate on impact, as previously mentioned, this disinflation is only transitory in the case of the fiscal dominance model, contrasting with the behavior observed in the monetary dominance model. Furthermore, the real exchange rate demonstrates a similar pattern: there is an appreciation of the real exchange rate following the contractionary monetary shock in both models. However, unlike traditional NK-SOE models, the fiscal dominance model exhibits a subsequent depreciation of the real exchange rate, which triggers a boom in the non-tradable sector—an outcome not observed in the monetary dominance model. Consequently, household consumption increases under the fiscal dominance regime, contrasting with traditional NK-SOE models. This behavior offers a potential explanation for the preference for such fiscal-monetary regimes: governments with a stronger relative preference for consumption over inflation are more likely to adopt fiscal dominance regimes due to the way these economies respond to exogenous shocks. In this sense, the relatively stronger performance of consumption under the fiscal dominance regime proves robust in the presence of external shocks, a topic that will be explored in greater detail in the next subsection.

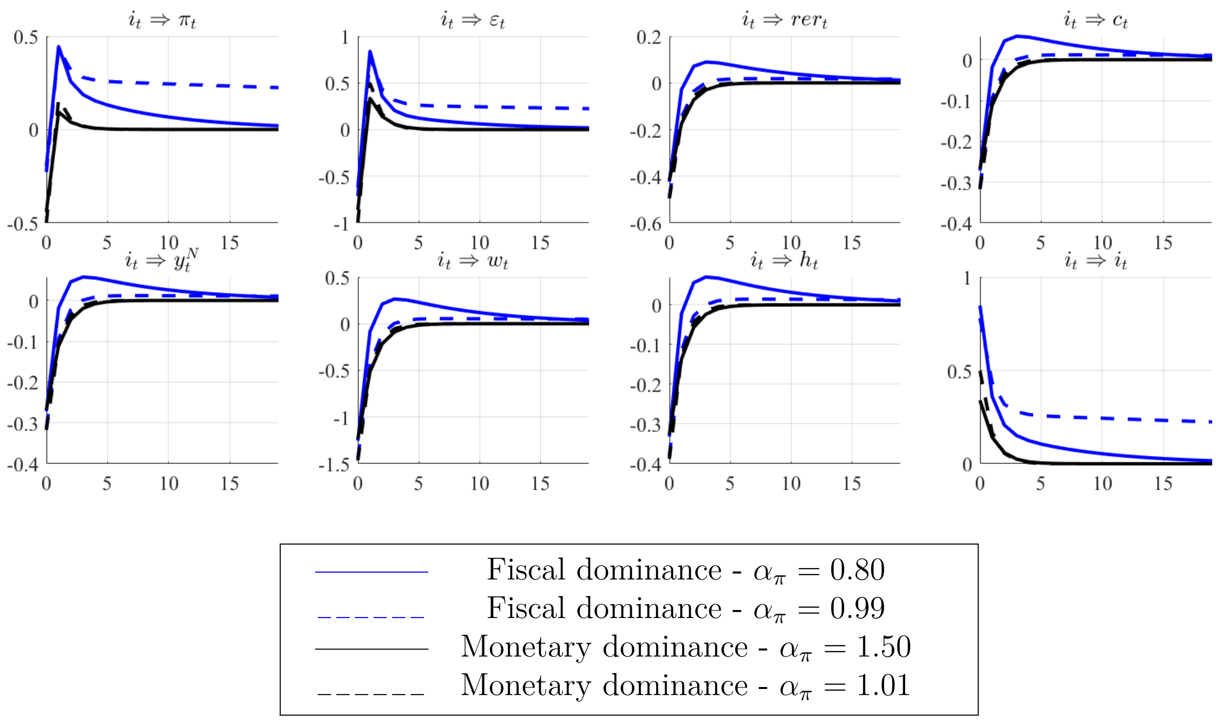

Figure 4: Impluse-response functions of inflation, exchange rate depreciation, real exchange rate, consumption, non-tradable output, wages and hours worked to a one standard deviation positive shock to the domestic interest rate.

As shown by Caramp & Silva (2023) in a closed economy setup, the size of the wealth effect heavily depends on the fiscal policy response to the shock. In terms of the intertemporal government budget constraint, an increase in the real interest rate reduces the net present value of primary surpluses. Under monetary dominance, lump-sum transfers must fall to offset this effect. This generates a negative income effect for households and further depresses desired consumption. By contrast, under fiscal dominance the fiscal response to the same shock is entirely different: the government keeps the real value of lump-sum transfers unchanged, so the negative income effect disappears. These differences in government behavior account not only for the more inflationary response of the fiscal-dominance regime, but also for the milder contraction in consumption.

Additionally, when comparing two alternative Taylor Rules for a fiscally-led economy, a generally counterintuitive outcome can be observed: a less aggressive interest rate response to inflation deviations (an α_π of 0.80) leads to faster inflation convergence. While this phenomenon is striking, it aligns with the expected behavior in an FTPL model.

3.1.2 External shocks

The reaction of both types of regimes to an increase in the international risk-free rate and to a drop in tradable endowment are contrasted in Figures 5 and 6.

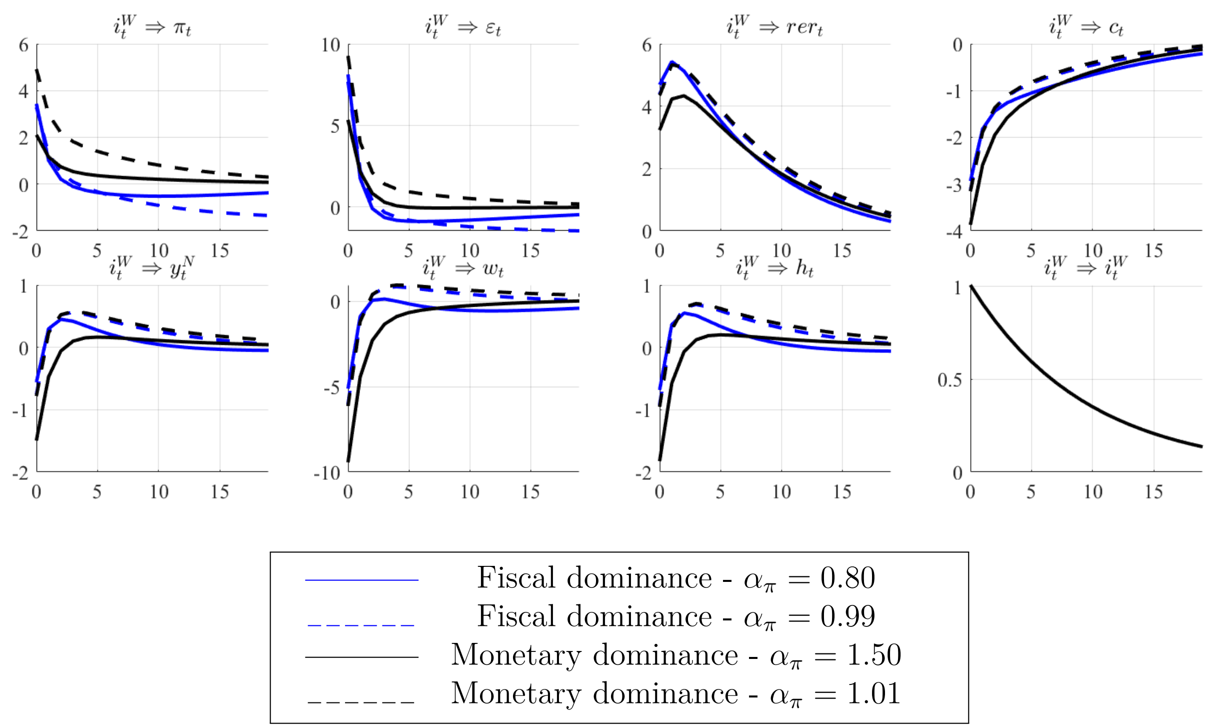

Figure 5: Impluse-response functions of inflation, exchange rate depreciation, real exchange rate, real domestic currency debt, consumption, non-tradable output, wages and hours worked to a one standard deviation positive shock to the international risk-free rate.

In the case of a shock to the international interest rate, there are no qualitative differences in the vast majority of the main endogenous variables of the model. The increase in the risk-free rate implies a negative wealth effect for the economy, given its position as a net debtor to the rest of the world. This negative effect, combined with the intertemporal channel, results in a decline in household consumption. There is an increase in the nominal exchange rate driven by the interest rate differential effect which, despite a degree of pass-through to inflation, generates a real depreciation. Consequently, a switching channel emerges, where tradable goods are substituted with non-tradable goods, eventually leading non-tradable output to exceed its steady-state value. The boom in the non-tradable sector constitutes the primary source of divergence between the two models: under fiscal dominance, there is an increase in the inflation rate and the nominal exchange rate, similar to the case of monetary dominance. However, this trend reverses over time, resulting in a nominal appreciation and an inflation rate below its steady-state value, as opposed to a monotonic convergence. This dynamic arises because the boom in the non-tradable sector generates an increase in labor income tax revenue, which in turn raises the present value of fiscal surplus flows. This fiscal channel does not exist under monetary dominance.

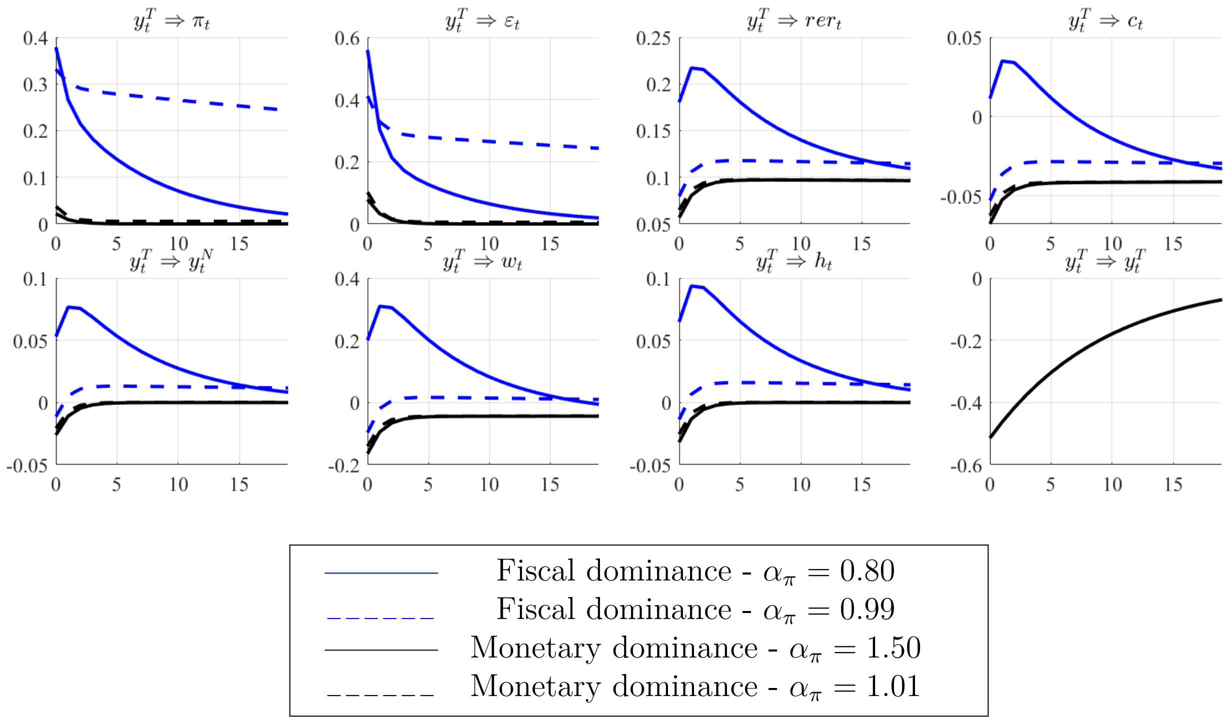

Figure 6: Impluse-response functions of inflation, exchange rate depreciation, real exchange rate, consumption, non-tradable output, wages and hours worked to a one standard deviation negative shock to the tradable output.

Figure 6 further explores the impact of a decrease in the tradable output endowment. Starting from the consumption response, it can be observed that the households' consumption reaction is less negative and even positive in the fiscal dominance model. More specifically, when the parameter governing the Taylor Rule is 0.80, consumption even increases at impact. This result is mainly driven by the weaker response of the interest rate to inflation deviations and the associated intertemporal-substitution channel through the real interest rate. This increase occurs alongside a real depreciation, which triggers a reallocation of expenditure to the non-tradable sector. On the other hand, the greater persistence in inflation and nominal depreciation in the fiscal dominance model, where the Central Bank reacts more aggressively to inflation deviations, is due to the particular characteristic of FTPL models: a larger increase in the nominal interest rate achieves the opposite effect to the expected one, delaying the convergence to the steady state.

3.2 Fixed exchange rate

The implementation of a fixed exchange rate regime in the context of an NK-SOE model with fiscal dominance causes the system to become unstable. In this sense, since a fixed exchange rate constitutes an active monetary policy, no equilibrium exists under an active fiscal policy regime. The government's commitment to maintaining a fixed parity implies, in terms of the FTPL equilibrium condition, that the treasury responds by achieving a flow of fiscal surpluses consistent with the debt stock at the predetermined parity. Cochrane (2023) mentions that foreign exchange pegs, when successful, are thus primarily fiscal commitments and communication devices. Many works explore the government's commitment to a rule for the price level and its conditioning on fiscal policy (Sims, 1997). It has also been commonly used as an explanation for currency and solvency crises (Daniel, 2001; Daniel, 2010).

4 Adding foreign debt: does the distribution matter?

A natural extension of the original model developed in section 2 is to allow the government to issue debt in foreign currency. In this regard, this section aims to explore whether the distribution of the type of debt the government chooses to issue (foreign or domestic currency-denominated debt) has any impact on the response of a fiscally-led economy to certain shocks. While the optimal choice of debt type by the government in this FTPL framework may be relevant and could serve as a topic for further research, to simplify the model and examine the specific effect of different borrowing rules, the following decision rule for the government is proposed:

$$\frac{rer^{SS} b_t^*}{b_t + rer^{SS} b_t^*} = \Omega \tag{17}$$

By following this rule, the government decides to maintain a constant share Ω of the total value of its debt in foreign currency.[11]

Given the inclusion of foreign currency-denominated debt, the equilibrium condition of the Fiscal Theory of the Price Level would become:

$$\frac{b_{t-1}}{1+\pi_t} + rer_t \frac{b_{t-1}^*}{1+\pi_t^*} = pvs_t \tag{18}$$

Now, the real exchange rate is also determined by the government debt valuation equation. In this regard, a particular and extreme case of this scheme would be when Ω takes a value of 1, that is, when the government decides to borrow exclusively in foreign currency. In this case, Cochrane (2023) argues that in a closed economy, with a fiscal surplus that does not react to the price level and foreign currency debt, the FTPL does not determine the price level. Moreover, it is not possible to implement an active fiscal policy with the non-default condition present in these types of models. Consequently, in a closed economy model with foreign currency debt and a government wanting to avoid default, the FTPL equation becomes a constraint on surpluses.

However, the model developed in this paper has two additional channels: (i) in a small open economy with tradable and non-tradable sectors, the real exchange rate serves as an adjustment variable that allows pinning down equation (18); (ii) the labor income tax, while not a function of the price level, relaxes Cochrane's assumption of a fiscal surplus that remains constant in real terms. In consequence, to address this potential channels, the reaction of the economy with a government that issues debt only in foreign currency is simulated for the two cases: (i) with labor income tax; (ii) without labor income tax.

Figure 7 shows the response of the economy to an expansionary fiscal policy. In this regard, in the model with labor income tax, it involves an increase in lump-sum transfers to households,

[11] To avoid short-run dynamics of the real exchange rate affecting the decision rule of the government, foreign currency-denominated debt is valued at the steady-state value of the real exchange rate (rer^{SS}).

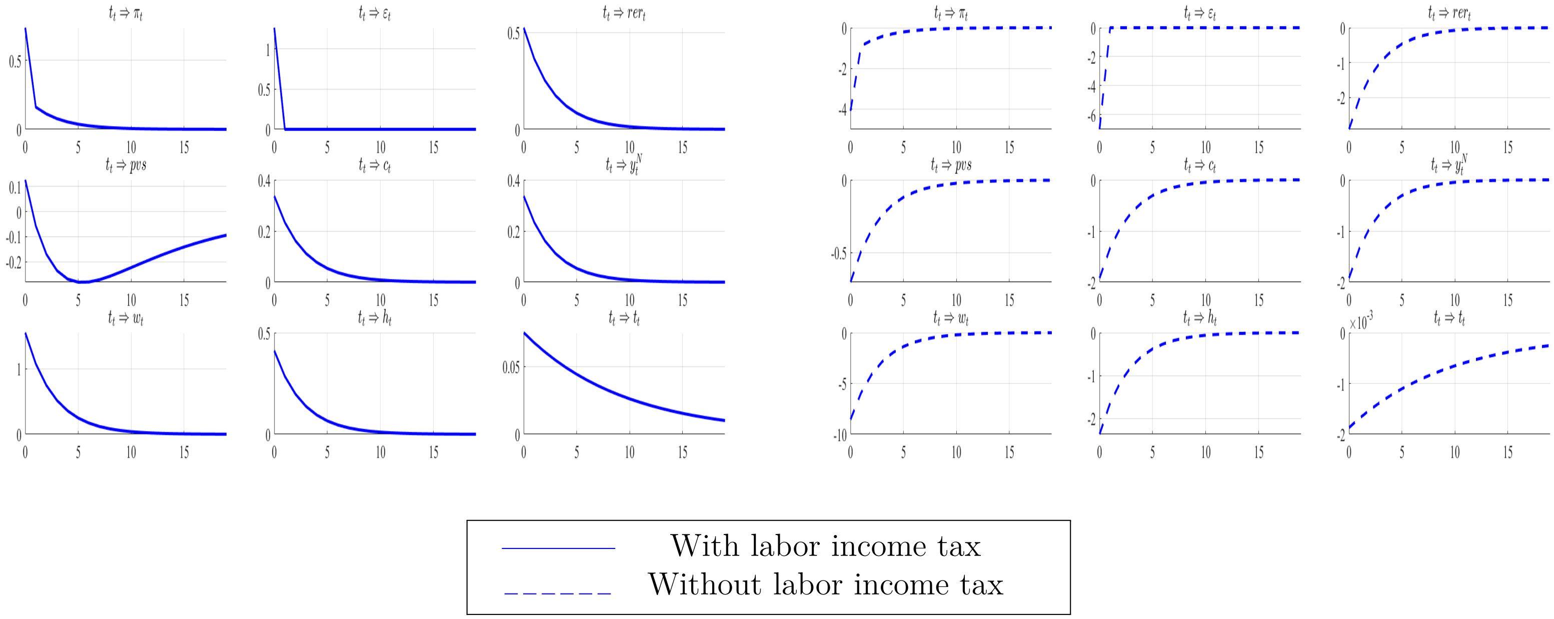

Figure 7: Impulse-response functions of inflation, exchange rate depreciation, present value of fiscal surpluses, real exchange rate, consumption, non-tradable output, wages, and hours worked to a one standard deviation expansionary fiscal shock.

while in the model without labor income tax, since both are calibrated to have the same fiscal surplus in steady state, it would imply a reduction in lump-sum taxes to households.

In the model with labor income taxation, the adjustment mechanism in the case of foreign currency-denominated debt relies on a boom in the non-tradable sector, driven by the increase in the real exchange rate. This boom leads to a rise in labor income tax revenues, along with a decline in the discount factor of fiscal surplus flows due to the increase in inflation and the nominal interest rate remaining constant given its AR(1) process. As a result, the present value of fiscal surpluses initially increases. However, it eventually falls below its steady-state value, reflecting the greater persistence of the fiscal shock relative to the temporary surge in the non-tradable sector and the inflationary spike. This case is, in essence, paradigmatic: an expansionary fiscal shock triggers such a response in inflation and the non-tradable sector that it initially leads to an increase in the present value of fiscal surpluses, thereby allowing for a reduction in the level of foreign-currency-denominated debt.

On the other hand, the model without labor income tax does not present the non-tradable sector boom channel since its revenue comes exclusively from lump-sum taxes to households.

Consequently, the only adjustment mechanism in the FTPL equation becomes the real exchange rate and the discount factor. In this way, in contrast to the previous case, the real exchange rate needs to appreciate (i.e. decrease) in order to reestablish the equilibrium condition. This is relevant given that, in the case with lump-sum taxes, the real exchange rate and its evolution become conditioned by fiscal solvency given the non-default assumption. As a result, the real exchange rate exhibits a completely different behavior: it appreciates in response to an expansionary fiscal shock, instead of depreciating.

Finally, to delve deeper into how the distribution of debt denomination affects the reaction of the economy to certain shocks, three alternative rules will be assumed:

1. **Only foreign currency debt:** $= 1$

2. **Equal currency distribution in debt:** $\Omega = 0.5$

3. **Only domestic currency debt:** $\Omega = 0$

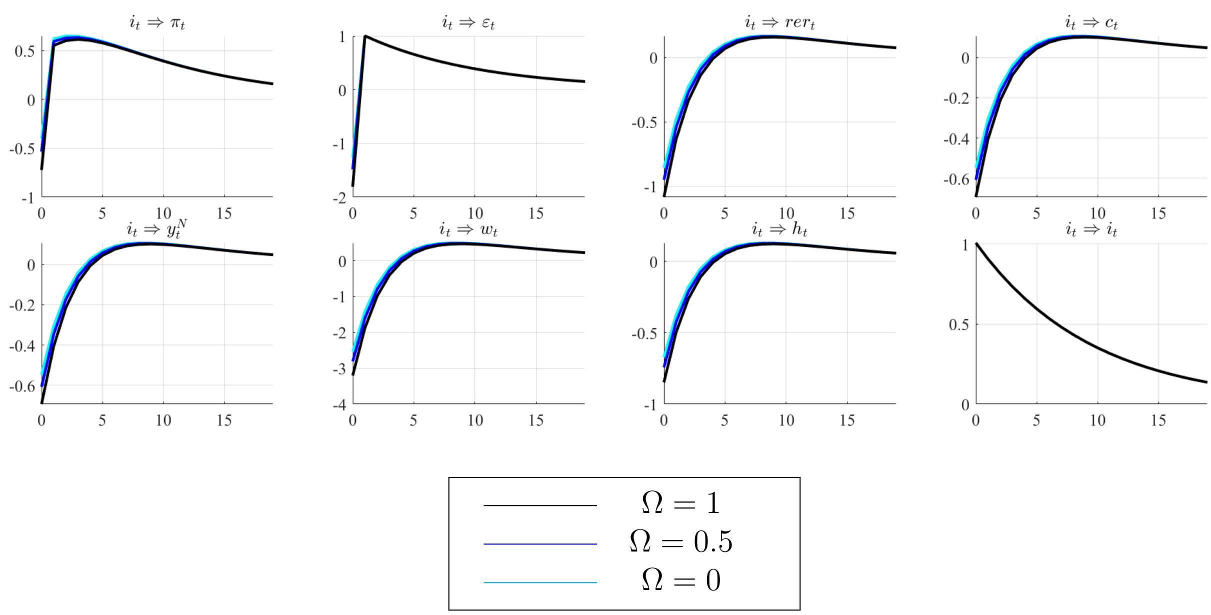

Figure 8: Impluse-response functions for inflation, exchange rate depreciation, real exchange rate, consumption, non-tradable output, wages and hours worked to a one standard deviation positive shock to the domestic interest rate.

Figure 8 displays the responses of the three alternative models to a contractionary monetary shock. Although there are no substantial differences in the reactions of the alternative models, a pattern arises: when the proportion of foreign debt is higher, the inflation rate is lower, and there is greater real appreciation. The main reason behind these facts is that, when there is foreign currency-denominated debt, the real exchange rate functions as a mechanism to restore the fiscal equilibrium condition by reducing the real value of this type of debt in domestic currency. Consequently, the inflation rate needed to inflate away domestic currency debt is naturally lower.

Figures 9 and 10 analyze the case of negative external shocks and how they propagate through the economy depending on the currency distribution chosen by the government for its debt. In general terms, a higher share of foreign currency-denominated debt is associated with greater real depreciation and, consequently, a more pronounced boom in the non-tradable sector. In this sense, the equilibrium condition imposed by fiscal dominance is key to understanding this phenomenon: the real depreciation increases the real value of foreign debt in domestic currency, which, naturally, becomes more pronounced as the share of foreign currency-denominated debt rises. In conclusion, the higher the share of foreign currency-denominated debt, the greater the required expansion in the non-tradable sector because of its impact on fiscal revenues, and the higher the inflation required given the smaller stock of domestic-currency-denominated debt (that is, the debt subject to being eroded by inflation).

On the other hand, since the nominal interest rate remains constant, the higher the inflation rate, the lower the real interest rate and, consequently, the larger the positive effect on current consumption via the intertemporal channel. This is the main reason behind the behavior of consumption across the different debt shares.

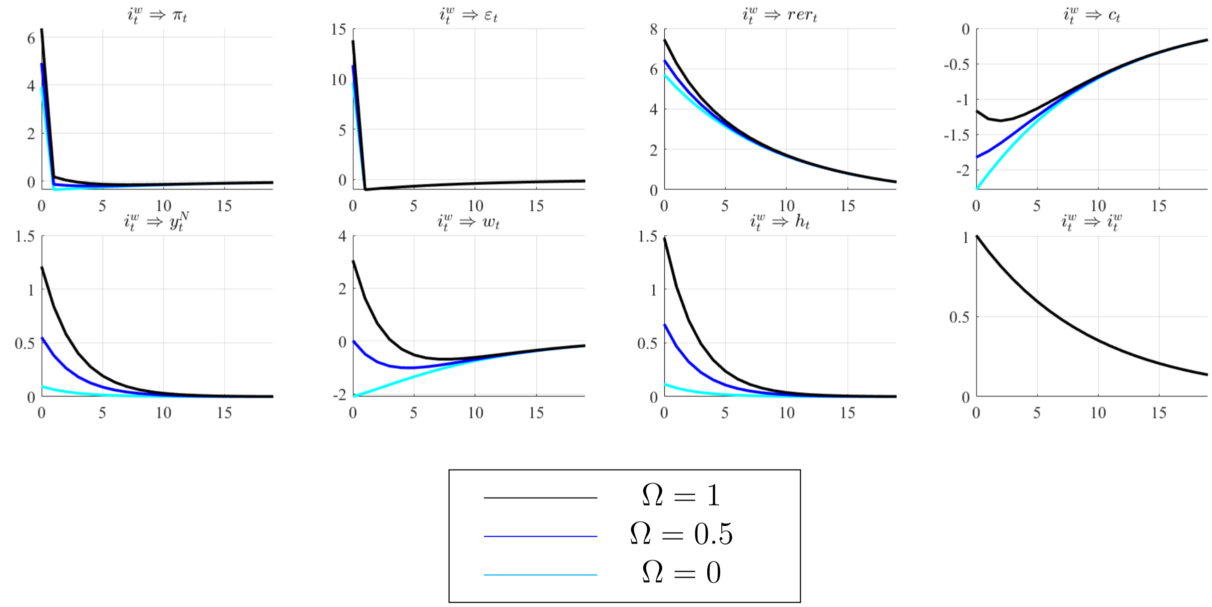

Figure 9: Impluse-response functions for inflation, exchange rate depreciation, real exchange rate, consumption, non-tradable output, wages and hours worked to a one standard deviation positive shock to the international risk-free rate.

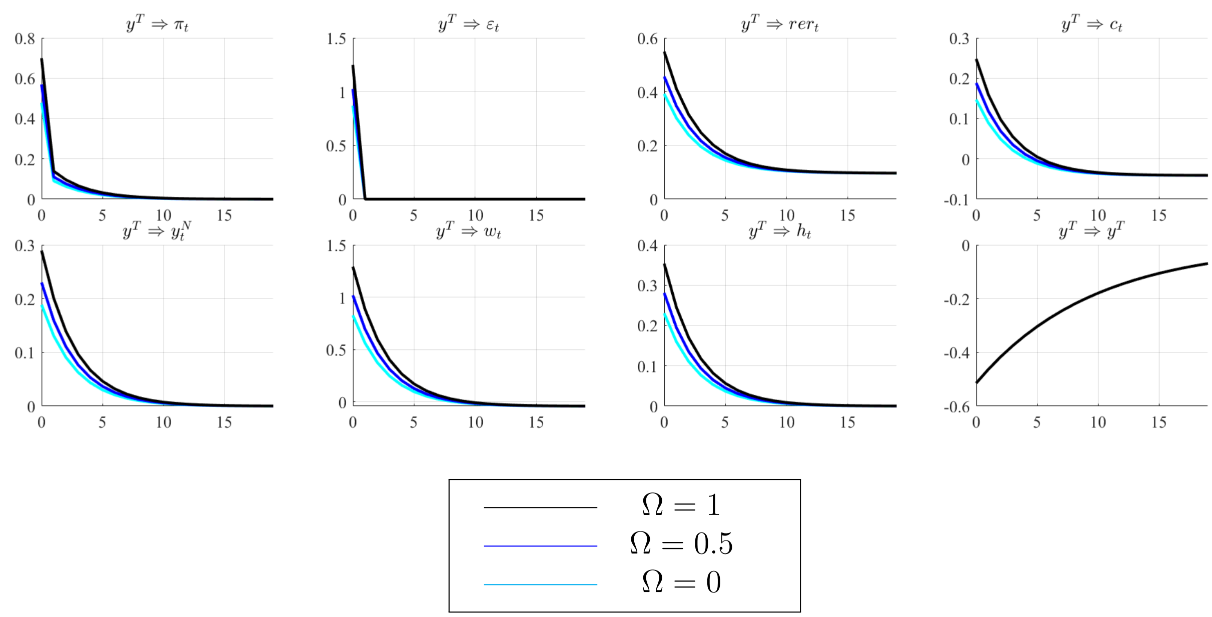

Figure 10: Impluse-response functions for inflation, exchange rate depreciation, real exchange rate, consumption, non-tradable output, wages and hours worked to a one standard deviation negative shock to the tradable output.

5 Conclusion

In this paper, I develop a New-Keynesian Small Open Economy model that incorporates fiscal dominance. Building on this framework, I analyze the potential differences in how economies respond to shocks depending on the fiscal-monetary regime in place. The results reveal significant deviations from traditional small open economy models. Specifically, these differences extend beyond nominal variables, such as the inflation rate or the nominal depreciation rate, to include real variables like household consumption levels. These findings offer potential explanations for why governments may adopt specific fiscal-monetary regimes, opening new avenues for research within the political economy literature.

Additionally, this paper is the first to examine the potential impact of the government's currency-denomination of debt within a small open economy that features fiscal dominance. More specifically, the findings suggest that a larger share of foreign currency-denominated debt is generally associated with greater real depreciation in response to negative external shocks, although this result is reversed in the case of contractionary monetary shocks. In this context, the structure of government revenues and expenditures plays a critical role and is far from neutral when foreign currency-denominated debt is present. For instance, when the government collects labor income tax from workers in the non-tradable sector, a fiscal shock leads to real exchange rate depreciation, triggering a boom in the non-tradable sector and increasing fiscal revenues. Conversely, when government revenue is fixed in real terms through lump-sum taxes, the real exchange rate appreciates instead, restoring the equilibrium condition for debt valuation via a reduction in the real domestic currency value of foreign debt.

These findings set the stage for future research on how the propagation of shocks is influenced by the structure of government revenues and expenditures. For example, incorporating taxes to the tradable sector could provide further insights into these dynamics.

References

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of monetary Economics*, 12(3), 383-398.

Caramp, N., & Silva, D. H. (2023). Fiscal policy and the monetary transmission mechanism. *Review of Economic Dynamics*, 51, 716-746.

Cochrane, J. H. (2018). Stepping on a rake: The fiscal theory of monetary policy. *European Economic Review*, 101, 354-375.

Cochrane, J. H. (2023). The Fiscal Theory of the Price Level. Princeton University Press.

Daniel, B. C. (2001). A fiscal theory of currency crises. *International Economic Review*, 42(4), 969-988.

Daniel, B. C. (2010). Exchange rate crises and fiscal solvency. *Journal of Money, Credit and Banking*, 42(6), 1109-1135.

Dixit, A. K., & Stiglitz, J. E. (1977). Monopolistic competition and optimum product diversity. *The American economic review*, 67(3), 297-308.

Gali, J., & Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies*, 72(3), 707-734.

Gorman, W. M. (1959). Separable utility and aggregation. *Econometrica: Journal of the Econometric Society*, 469-481.

Hazell, J., & Hobler, S. (2024). Do Deficits Cause Inflation? A High Frequency Narrative Approach. Technical report.

Hnatkovska, V. V., Lahiri, A., & Vegh, C. A. (2012). The exchange rate response puzzle. *Available at SSRN 1996693*.

Jiang, Z. (2022). Fiscal cyclicality and currency risk premia. *The Review of Financial Studies*, 35(3), 1527-1552.

Kohlscheen, E. (2014). The impact of monetary policy on the exchange rate: A high frequency exchange rate puzzle in emerging economies. *Journal of International Money and Finance*, 44, 69-96.

Leeper, E. M. (1991). Equilibria under 'active' and 'passive' monetary and fiscal policies. *Journal of monetary Economics*, 27(1), 129-147.

Mendoza, E. G., & Uribe, M. (2000). Devaluation risk and the business-cycle implications of exchange-rate management. In *Carnegie-Rochester Conference Series on Public Policy* (Vol. 53, No. 1, pp. 239-296). North-Holland.

Ottonello, P., & Perez, D. J. (2019). The currency composition of sovereign debt. *American Economic Journal: Macroeconomics*, 11(3), 174-208.

Romelli, D. (2024). Trends in central bank independence: a de-jure perspective. *BAFFI CAREFIN Centre Research Paper*, (217).

Sargent, T. J., & Wallace, N. (1981). Some unpleasant monetarist arithmetic. *Quarterly Review*, 5(Fall).

Schmitt-Grohé, S., & Uribe, M. (2001). Stabilization policy and the costs of dollarization. *Journal of money, credit and banking*, 482-509.

Schmitt-Grohé, S., & Uribe, M. (2003). Closing small open economy models. *Journal of international Economics*, 61(1), 163-185.

Senhadji, A. S. (1994). *Adjustment of a small open economy to external shocks*. University of Pennsylvania.

Sims, C. A. (1994). A simple model for study of the determination of the price level and the interaction of monetary and fiscal policy. *Economic theory*, 4, 381-399.

Sims, C. A. (1997). Fiscal foundations of price stability in open economies. Unpublished manuscript, Princeton University.

Strotz, R. H. (1957). The empirical implications of a utility tree. *Econometrica: Journal of the Econometric Society*, 269-280.

Uribe, M., & Schmitt-Grohé, S. (2017). *Open economy macroeconomics*. Princeton University Press.

Woodford, M. (1995). Price-level determinacy without control of a monetary aggregate. In *Carnegie-Rochester conference series on public policy* (Vol. 43, pp. 1-46). North-Holland.

Appendix I

The equilibrium conditions of the model developed in Section 2:

$$\lambda_t = c_t^{-\sigma} \tag{E.1}$$

$$\lambda_t (1-\tau) w_t = h_t^{\phi} \tag{E.2}$$

$$\lambda_t = \beta(1+i_t^*)\mathbb{E}_t \left[\frac{\lambda_{t+1}(1+\varepsilon_{t+1})}{(1+\pi_{t+1})} \right] \tag{E.3}$$

$$\lambda_t = \beta(1+i_t)\mathbb{E}_t \left[\frac{\lambda_{t+1}}{(1+\pi_{t+1})} \right] \tag{E.4}$$

$$\frac{b_t^H}{1+i_t} + rer_t \frac{b_t^{*H}}{1+i_t^*} + p_t^T c_t^T = p_t^T y_t^T - \tau w_t h_t + t_t + \frac{b_{t-1}^H}{1+\pi_t} + rer_t \frac{b_{t-1}^{*H}}{1+\pi_t^*} \tag{E.5}$$

$$c_t = \left[(1-\omega)^{\frac{1}{\eta}} (c_t^T)^{\frac{\eta-1}{\eta}} + \omega^{\frac{1}{\eta}} (c_t^N)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{E.6}$$

$$c_t^T = (1-\omega) \left(p_t^T\right)^{-\eta} c_t \tag{E.7}$$

$$c_t^N = \omega \left(p_t^N\right)^{-\eta} c_t \tag{E.8}$$

$$1 = \theta \left(1+\pi_t^N\right)^{\mu-1} + (1-\theta) \left(\tilde{p}_t^N\right)^{1-\mu} \tag{E.9}$$

$$y_t^N = c_t^N \tag{E.10}$$

$$b_t^H = b_t \tag{E.11}$$

$$pvs_t = \tau w_t h_t - t_t + \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} pvs_{t+1} \tag{E.12}$$

$$\frac{b_{t-1}}{1+\pi_t} = pvs_t \tag{E.13}$$

$$pvmc_t = \frac{1}{\alpha} \left(y_t^N\right)^{\frac{1}{\alpha}} w_t \left(\tilde{p}_t^N\right)^{-\frac{\mu}{\alpha}} + \beta\theta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{\tilde{p}_t^N}{\tilde{p}_{t+1}^N} \frac{1}{1+\pi_{t+1}^N} \right)^{-\frac{\mu}{\alpha}} pvmc_{t+1} \tag{E.14}$$

$$pvmr_t = \frac{\mu-1}{\mu} y_t^N p_t^N \left(\tilde{p}_t^N\right)^{1-\mu} + \beta\theta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{\tilde{p}_t^N}{\tilde{p}_{t+1}^N} \frac{1}{1+\pi_{t+1}^N} \right)^{1-\mu} pvmr_{t+1} \tag{E.15}$$

$$pvmc_t = pvmr_t \tag{E.16}$$

$$y_t^N = \chi_t^{-\alpha} h_t^{\alpha} \tag{E.17}$$

$$\chi_t = \theta \chi_{t-1} (1+\pi_t^N)^{\frac{\mu}{\alpha}} + (1-\theta) \left(\tilde{p}_t^N\right)^{-\frac{\mu}{\alpha}} \tag{E.18}$$

$$1 + i_t^* = 1 + i_t^W + \psi(e^{(b_t^{*H} - \overline{b^{*H}})} - 1) \tag{E.19}$$

$$rer_t = p_t^T \tag{E.20}$$

$$\frac{p_t^T}{p_{t-1}^T} = \frac{(1+\varepsilon_t)(1+\pi_t^*)}{(1+\pi_t)} \tag{E.21}$$

$$\frac{p_t^N}{p_{t-1}^N} = \frac{(1+\pi_t^N)}{(1+\pi_t)} \tag{E.22}$$