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Fiscal Rules and Optimal Currency Composition of Sovereign Debt in Emerging Economies

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Abstract

Total public debt in most emerging markets grew before and after the pandemic with a sizable share in foreign currency. Along this trend, interest payments increased even in the presence of active fiscal rules in some countries. How should debt management of public debt be set under a fiscal rule? This document studies how optimal currency composition reduces the cost of debt and facilitates fiscal rule compliance but increases budget risk. Using a small open economy model, we provide evidence that optimal foreign currency holdings in Chile, Colombia and Mexico depart considerably from observed; remaining low (high) in periods of favorable (adverse) external or domestic macroeconomic and financial conditions.

JEL codes: E61, E62, H63.

Keywords: sovereign debt management, fiscal rules, currency composition.

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1 Introduction

Over the past decades, sovereign debt in emerging markets (EMs') increased to a US$7 trillion market that represented around 37 percent of EMs' GDP in 2006 and reached 57% of GDP by the end of 2020. Along this path, the overall share of foreign currency debt decreased 3 percentage points to 37 percent share of total debt. Both the level and composition of sovereign debt showed different dynamics across and within EMs' blocs. In particular, EMs from Africa described a sustained increase in debt-to-GDP ratios since the global financial crises with a transitory reduction before the pandemic, while Latin American EMs increased their debt steadily since the commodity price shock. Conversely, emerging Europe and Asia to managed keep a stable path of debt (Figure. 1a). On the other hand, the preference for foreign currency has been heterogeneous and remains sizable in some cases. For instance, Latin America experienced a steady increase in the share of foreign currency after the global financial crisis while Africa had a sudden increase after the commodity price shock of 2014 (Figure 1b).

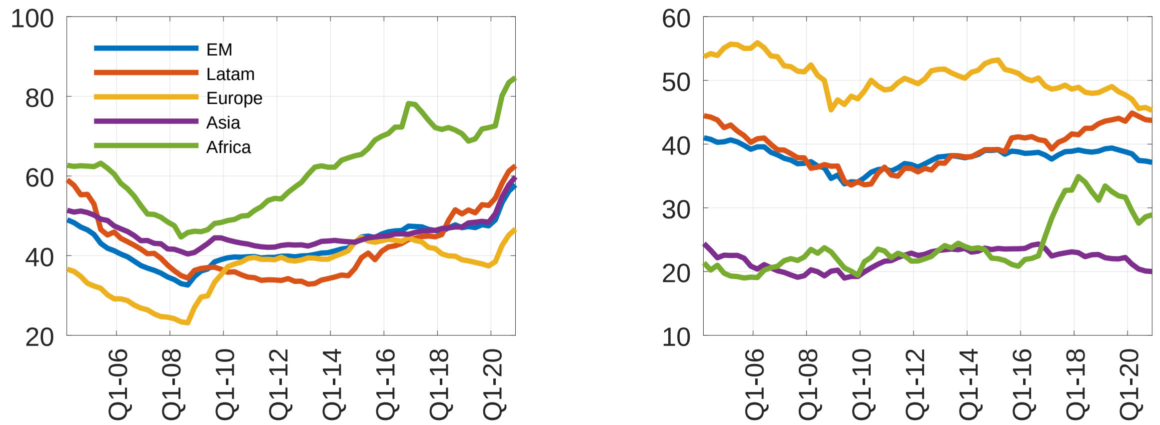
Moreover, the differences in the pace of debt accumulation took place despite common financial and macroeconomic shocks and, in some cases, despite active fiscal policy. In this period, many EM countries engaged in fiscal rules implementation to ensure fiscal sustainability and to build enough fiscal buffers to smooth adverse shocks. The choice and nature of these rules have been broad in their objectives as well as their instruments and scope. Some rules focus on specific budget or debt limit or on growth of public spending or revenue. For the specific case of EMs oriented towards commodity exports it is compelling to fit their fiscal rules to commodity fiscal revenue considerations to cope with cyclical fluctuations. On the other hand, debt management policy is usually explored separately as a complementary tool in the broad fiscal framework toolkit to reduce budget risk and contribute to debt reduction and sustainability.

The connection between fiscal rules and debt management policy has not been exploited thoroughly. Empirical evidence has explored how well-designed fiscal rules contribute to ensure fiscal sustainability (e.g., Neyapti, 2013, Benito, Bastida, & Vicente, 2013) or to reduce the probability of a sudden stop gomez2021fiscal. On debt management policy, the literature has addressed how a proper debt profile contributes risk management and reduces financing cost.[1] In particular, evidence shows that currency composition is related to the diversification of debt holders, distribution between local and global risk and to the consolidation of domestic financial market ((Miyajima, Mohanty, & Chan, 2015, Claessens, Klingebiel, & Schmukler, 2007). The fiscal rule and debt management frameworks interact with each other, in several ways, one of them is that a sudden increase of interest payments might abruptly deviate the budget balance or debt level from target and lead to unwarranted increase of distortionary taxes or fiscal consolidations. This is particularly more relevant for countries with an upward trend of debt.

How should the currency composition of public debt be set under fiscal rule? On this issue, Bohn, 1990 builds a taxation-smoothing model in which the government aims to minimize tax distortions to smooth consumption by choosing the currency composition of debt. In the model,

[1] Missale, 1997 elaborates on aspects in which debt management policies such as currency composition contributes to overall economic policy and encompass time consistency, risk sharing among economic agents and market efficiency by reducing incomplete market failures.

Figure 1: Gross Public Debt-to-GDP ratio in Emerging Markets.



(a) Gross public debt

(b) Share of foreign currency debt

Source: International Financial Statistics of the International Monetary Fund and Arslanalp & Tsuda, 2014.The data set covers Argentina, Brazil, Bulgaria, Chile, China, Colombia, Egypt, Hungary, India, Indonesia, Latvia, Lithuania, Malaysia, Mexico, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey, Ukraine and Uruguay.

foreign currency debt issuance emerges as an alternative hedging tool to overcome macroeconomic shocks and highlights the trade-off between minimizing tax distortions and minimizing budget risk. We extend this analytical approach using a small open economy general equilibrium model with nominal rigidities where the government minimizes tax distortions choosing the optimal currency composition of debt given a structural fiscal rule. The fiscal rule supports an implicit level of public debt and uses as policy instrument the tax rate. The model includes a central bank that reacts to inflation increase using the nominal interest rate, thus shutting down the incentives of the government to dilute local currency debt through domestic prices.

The model is estimated for three specific EMs commodity-exporting countries that have similar fiscal rules, namely Chile, Colombia, and Mexico.[2] In these countries, the public debt-to-GDP ratios increased as well as the share of foreign currency debt at different pace. The public debt dynamics in these countries are mostly explained by interest rate payments and to a lesser extend by the nominal exchange rate depreciation and primary deficit. Conversely, economic growth and inflation contributed negatively. Table 1 shows the standard public debt dynamics accounting for 2011-2019 and 2020. The table describes how interest payments are the most salient underlying factor explaining the change of debt in Colombia and Mexico but not in Chile. Additionally, the nominal exchange rate depreciation is particularly important in Colombia and Mexico.[3] On the other hand, the primary balance explains most of the change in

[2]These countries have a structural balance approach of fiscal rules to take into account cyclical features of public finances due to their exposure to commodities shocks and related factors. For more details see Barreix et al., 2019.

[3]This is particularly related to the 2014 commodity price shock. In that year, oil and copper prices dropped 45% and 13%, respectively. The price decline led to a sharp economic growth contraction in Colombia and Mexico for oil and Chile for copper because of the significant exposure to commodity exports (48%, 13% and 52% from total exports). The shock implied a significant drop of the terms of trade in Colombia (28%), Mexico (14%) while Chile experienced no variation. These governments relied on different policies such as tax bills, oil

debt in Chile contrary to the other countries. In 2020, the underlying factors that contributed to debt dynamics focused mainly on the primary balance and growth deterioration due to the COVID-19 shock. In this episode, the three countries experienced a rapid reduction of both commodity and non-commodity fiscal revenue and increasing public health spending.

Overall, the debt dynamics decomposition captures the relevance of debt management in a context of ongoing fiscal rules. In this period, interest payments and exchange rate depreciation explain most of the debt dynamics and are key factors of debt management policy. Even in a context of a fiscal rule it could be the case that macroeconomic or financial shocks increase financing cost and compromise the rule compliance. The estimated model shows that there is room for debt management policy. The average deviation from optimal share of local currency for 2011-2020 is 4% below optimal for Colombia, 1% above optimal in Chile and 2% below optimal in Mexico. These deviations vary around two key macroeconomic events, the commodity price shock and the recent pandemic. Additionally, observed foreign currency debt seems to increase in the economic downturn and exhibits difficulty in reaching optimal levels afterwards.

Table 1: Summary of Debt Dynamics for Chile, Colombia and Mexico between 2011 and 2020

	Pre-pandemic			Pandemic		
	Chile	Colombia	Mexico	Chile	Colombia	Mexico
Average public debt: (% of GDP)	18.5	42.6	42.6	32.5	64.8	53.9
Change in public debt: (percentage points)	19.7	11.9	13.6	4.3	14.5	7.1
Contribution to the change of debt:						
Interest payments	5.7	25	23.8	0.7	3	2.1
Inflation	-4.8	-14.3	-16	-2.2	-0.7	-1.4
Growth	-3.6	-12	-8	1.6	3.6	4.1
Depreciation	1.6	9.5	6.6	0.1	2.5	0.8
Primary balance	6.2	2.3	1.1	6.3	5.4	-0.1
Other flows	14.6	1.5	6.1	-2.2	0.6	1.1
Average share of foreign public debt: (% of total)	22	42	45	29	51	38

Source: Ministry of Finance in each country and authors' calculations. The level of government is central government.

funds transfers, public spending cuts to preserve public debt sustainability.

This document is divided as follows: Section 2 provides a brief review of literature on debt management. Section 3 depicts the model, Section 4 shows the calibration and estimation and Section 5 concludes.

2 Literature Review

Our approach relates to the currency composition literature of debt management policy. Following the seminal contributions of Kydland & Prescott, 1977 and Barro & Gordon, 1983 on time inconsistency, well-designed fiscal rules and debt management policy act as frameworks to improve commitment. In particular, our model follows to that of Bohn, 1990 who builds a taxation smoothing model in which the government minimizes tax distortions to smooth consumption by choosing a debt structure in which foreign currency debt issuance emerges as an alternative hedging tool. Other debt management policy issues include term structure, foreign currency revenue matching, investors' base diversification, available sources of funding, or domestic financial development versus foreign (Missale, 1997 and Claessens et al., 2007). We focus on currency aspects of debt management which generate important specific risks. In this framework, Li & Panizza, 2013 detail how failing to cope with a risky debt structure reduces the options of debt managers to respond to crises due to currency mismatches or insufficient funding.

A major source of budgetary risk is the inability of EMs to access the international markets financing in their own currency eichengreen2002original.[4] High levels of sovereign debt in foreign currency increase fiscal vulnerability to abrupt depreciation of the nominal exchange rate or increase of foreign interest rates. Many, EMs countries changed towards local currency debt to have less exposure to global factors and improvements in monetary policy credibility (e.g., Du & Schreger, 2016, Du, Pflueger, & Schreger, 2020). However, the trend is heterogeneous. Evidence shows that for some developing and EM countries debt composition is related to institutional factors such as capital controls forslund2011determinants or access to international markets through concessional external debt from international institutions beaugrand2002choice.

On the other hand, under limited commitment of monetary policy the incentives to increase local currency are high due to debt dilution from high inflation rates. From an endogenous default perspective, Engel & Park, 2022 and Ottonello & Perez, 2019 investigate the role of strategic dilution of debt through inflation and default on currency composition of debt. The value of local currency debt can be changed by the monetary policy but increases the incentives to deviate from disciplined monetary management. In our model, the government budget constraint internalizes the nominal exchange rate and foreign interest rates. Additionally, the strategic behavior of government on debt dilution is shutdown using a credible monetary policy stance through a central bank that uses interest rates as instruments to react to inflation increases.[5]

[4]In this paper, we abstract from the holders' composition in which foreign holders own local market debt and therefore there is additional vulnerability on local debt.

[5]An alternative approach is to use financial instruments in the debt structure such as inflation-protected instruments where any inflation increase raises the interest rate payments. Gomez-Gonzalez, 2019 explores the role of inflation-linked public debt using a two-sector small open economy model where exchange rate

3 Model Environment

We consider a small open economy in discrete time and indexed by t. The economy is populated by households, firms, and government. The representative household's preferences include Edgeworth complementarity (or substitutability) between private and public consumption and disutility of labor.[6] Additionally, households own private capital that exhibits adjustment cost. Firms can produce goods locally or import. Both local production and imported goods are divided between final and intermediate goods. Nominal rigidities are introduced with Calvo pricing setting for both domestic and import prices. The government aims to minimize the distortionary tax rate budget to the budget constraint. Finally, there is a central bank that uses interest rate as an instrument that responds to inflation deviation from its target.

3.1 Households

The representative household solves two problems: (i) maximizes the expected utility over an infinite horizon subject to a budget constraint and (ii) minimizes the cost of consumption given a set of prices. The first problem is written as:

$$\max_{\left\{c_t, n_t, k_{t+1}, x_t, b_t^d, b_t^*\right\}_{t=0}^{\infty}} E_t\left[\sum_{t=0}^{\infty} \beta^t\left(\log\left(c_t+\alpha_g g_t\right)-\eta \frac{n_t^{1+\nu}}{1+\nu}\right)\right] \tag{1}$$

$s.t:$

$$c_t + x_t + b_t^d + rer_t b_t^* = [1-\tau_t]\left[w_t n_t + r_t^k k_t\right] + (1+r_{t-1}) b_{t-1}^d + \left(1+r_{t-1}^*\right) rer_t b_{t-1}^* \tag{2}$$

$$k_{t+1} = (1-\delta) k_t + x_t - \frac{\vartheta}{2}\left(\frac{x_t}{k_t}-\delta\right)^2 k_t, \tag{3}$$

Where E_t is the expectation operator, conditioned on information available up to period t and $\beta \in (0,\,1)$ is the discount factor. α_g is the degree of complementarity/substitutability parameter between private consumption c_t and public spending g_t as in Fève, Matheron, & Sahuc, 2013.[7] Labor supply is n_t, the Frisch elasticity of labor supply is $1/\nu$ and η is a scale parameter. Furthermore, x_t denotes spending in investment, rer_t the real exchange rate —increase means depreciation—, and w_t is wage rate. Moreover, k_t and r_t^k represent capital and the price of capital, while δ is the depreciation rate. Lastly, b_t^d and b_t^* are domestic and foreign bonds, r_t and r_t^* are their corresponding real interest rates, and τ_t is a tax levied on labor income and capital returns.

depreciation acts as a motive to issue local currency debt linked to inflation.

[6] Weber, 2005 explores the theoretical foundations of this type of preferences. Recently, it has gained attention as a way to model potential fiscal multipliers of government spending.

[7] For a value of $\alpha_g = 1$, there is perfect substitution, thus a permanent increase in government spending has no effect on output and labor supply but reduces consumption due to the crowding-out effect. In the case of $\alpha_g < 0$ government spending is complementary.

The first order conditions are given by:

$$[c_t] : \lambda_t = \frac{1}{c_t + \alpha_g g_t} \tag{4}$$

$$[n_t] : \eta n_t^{\nu} = [1 - \tau_t] \lambda_t w_t \tag{5}$$

$$[k_{t+1}] : \mu_t = \beta E_t \Big[\lambda_{t+1} r_{t+1}^k (1 - \tau_{t+1}) + \mu_{t+1}(1 - \delta)\Big] \tag{6}$$

$$\left[b_t^d\right] = [b_t^*] : rer_t = E_t \left[rer_{t+1} \frac{(1 + r_t^*)}{\left(1 + r_t^b\right)}\right] \tag{7}$$

Note that the first order conditions for consumption (4) describes the effect of government spending on the consumption path of households. This consumption path of private households internalizes government spending but not taxes or government borrowing, thus an increase of government consumption crowds out private consumption if $\alpha \geq 1$. Additionally, because of the labor-leisure trade-off ((4) and (5)) the reduction in consumption increases labor supply. Likewise, from the first order condition of capital (6) describes the consumption/investment decision.

In the second problem of households, consumption can be allocated to domestic and imported goods. In this setting, households aim to minimize consumption cost choosing the optimal path of both domestic and imported demand of goods c_t^d, c_t^m given their prices p_t^d, p_t^m and the aggregate level of consumption c_t. The problem is given by:

$$\min_{\left\{c_t^d, c_t^m\right\}_{t=0}^{\infty}} \quad p_t^d c_t^d + p_t^m c_t^m \tag{8}$$

$$s.t.$$

$$c_t = \left[\psi_c^{\frac{1}{\omega_c}} c_t^{d^{\frac{\omega_c - 1}{\omega_c}}} + (1 - \psi_c)^{\frac{1}{\omega_c}} c_t^{m^{\frac{\omega_c - 1}{\omega_c}}}\right]^{\frac{\omega_c}{\omega_c - 1}} \tag{9}$$

ψ_c is the share of consumption of domestic goods in aggregate consumption and captures a measure of home bias while and ω_c is the elasticity of substitution parameter between domestic and foreign goods that reflects the degree of economy openness. The first order conditions are given by:

$$\left[c_t^d\right] : c_t^d = \psi_c \left(\frac{p_t^d}{p_t}\right)^{-\omega_c} c_t \tag{10}$$

$$[c_t^m] : c_t^m = (1 - \psi_c) \left(\frac{p_t^m}{p_t}\right)^{-\omega_c} c_t \tag{11}$$

The demand functions of both domestic and foreign goods are inverse functions of the relative prices and proportional to total demand. On the other hand, the price index of aggregate consumption is set to the unity as follows:

$$1 = \psi_c \left(p_t^d\right)^{1-\omega_c} + (1 - \psi_c) \left(p_t^m\right)^{1-\omega_c} \tag{12}$$

3.2 Firms

Final good firms produce a homogeneous good in perfect competition. The problem of final good firms is to maximize profits by choosing differentiated intermediate goods ($y_{z,t}$) subject to a technology of production that follows a Dixit-Stiglitz aggregation function across intermediate goods:

$$y_t = \left[\int_0^1 (y_{z,t})^{\frac{\theta-1}{\theta}} \, dz\right]^{\frac{\theta}{\theta-1}} \tag{13}$$

Where θ is the parameter of the elasticity of substitution among intermediate goods. Thus the problem of the final firm is:

$$\max_{\{y_{z,t}\}_{t=0}^{\infty}} \quad p_t^d \, y_t - \int_0^1 p_{z,t}^d \, y_{z,t} \, dz \tag{14}$$

$$s.t.$$

$$y_t = \left[\int_0^1 (y_{z,t})^{\frac{\theta-1}{\theta}} \, dz\right]^{\frac{\theta}{\theta-1}}$$

The first order condition gives the standard demand curve for each intermediate good:

$$y_{z,t} = \left(\frac{p_{z,t}^d}{p_t^d}\right)^{-\theta} y_t \tag{15}$$

With p_t^d being the standard domestic price index:

$$p_t^d = \left(\int_0^1 \left(p_{z,t}^d\right)^{1-\theta} dz\right)^{\frac{1}{1-\theta}} \tag{16}$$

In the case of intermediate goods firms, each firm z solves two problems: (i) choosing labor and capital such that the total cost is minimized and (ii) choosing the path of prices to maximize the expected path of profits. The minimization of total cost of each z firm is subject to a common technology of production and is given by:

$$\min_{\left\{n_{z,t},k_{z,t}\right\}_{t=0}^{\infty}} \quad w_t n_{z,t} + r_t^k k_{z,t} \tag{17}$$

$$s.t.$$

$$y_{z,t} = z_t k_{z,t}^{\alpha} n_{z,t}^{1-\alpha}$$

Here, z_t is a total productivity shock that follows an AR(1) process with normally distributed *iid* and α is the share of capital in the production function. The optimal levels of capital and labor demanded by the intermediate goods producing firms are:

$$[k_{z,t}] : \frac{k_{z,t}}{y_{z,t}} = \frac{\alpha \, mc_t}{r_t^k} \tag{18}$$

$$[n_{z,t}] : \frac{n_{z,t}}{y_{z,t}} = \frac{(1-\alpha)\, mc_t}{w_t} \tag{19}$$

The previous expressions denote that the optimal level of capital and labor is achieved when the marginal product of each factor equals its marginal cost (mc_t).

The second problem for each firm z is to choose the path of prices such that the expected profits are maximized with probability ε, subject to the inverse demand function y_t:

$$\max_{\left\{p^d_{z,t}\right\}^{\infty}_{t=0}} \quad E_t \left[\sum_{i=0}^{\infty} \varepsilon^i \frac{\lambda_{t+i}}{\lambda_t} \left(\frac{p^d_{z,t+i}}{p^d_{t+i}} - mc_{t+i} \right) y_{z,t+i} \right] \tag{20}$$

s.t.

$$E_t \left[y_{z,t+i} \right] = E_t \left[\frac{p^d_{z,t+i}}{p^d_{t+i}}^{-\theta} y_{t+i} \right]$$

The first order condition yields the optimal adjustment of the prices, where θ is not only the parameter of the degree of substitution between goods produced by z firms, but also describes the grade of monopoly of each firm:

$$\frac{p^*_t}{p^d_t} = \frac{\theta}{\theta-1} \frac{E_t \left[\sum_{i=0}^{\infty} (\beta\varepsilon)^i \frac{\lambda_{t+i}}{\lambda_t} mc_{t+i} \left(\frac{p^d_{t+i}}{p^d_t} \right)^{\theta} \right]}{E_t \left[\sum_{i=0}^{\infty} (\beta\varepsilon)^i \frac{\lambda_{t+i}}{\lambda_t} \left(\frac{p^d_{t+i}}{p^d_t} \right)^{\theta-1} \right]} \tag{21}$$

Similarly, the price formation of the importers follows a Calvo price-setting.

$$\max_{\{p^m_t\}^{\infty}_{t=0}} E_t \left[\sum_{i=0}^{\infty} \varepsilon^i \frac{\lambda_{t+i}}{\lambda_t} \left(\frac{p^m_{t+i}}{p_{t+i}} - e_{t+i} p^*_{t+i} \right) c^m_{z,t+i} \right] \tag{22}$$

Finally, the first order condition entails the optimal adjustment of the prices:

$$p^{m^*}_t = \frac{\omega_c}{\omega_c - 1} \frac{E_t \left[\sum_{i=0}^{\infty} (\beta\varepsilon)^i \frac{\lambda_{t+i}}{\lambda_t} e_{t+i} p^*_{t+i} \left(\frac{p_{t+i}}{p_t} \right)^{\omega_c} \right]}{E_t \left[\sum_{i=0}^{\infty} (\beta\varepsilon)^i \frac{\lambda_{t+i}}{\lambda_t} \left(\frac{p_{t+i}}{p_t} \right)^{\omega_{c-1}} \right]} \tag{23}$$

3.3 Government

The government seeks to minimize tax distortion cost which is represented as a function of the tax rate deviation its steady state. Unlike Bohn, 1990, the minimization problem includes explicitly cost related to domestic debt share following a similar convex (quadratic) function. The optimization problem the government aims to solve is:

$$\min_{\{h_t\}_{t=0}^{\infty}} E_t \left[\sum_{t=0}^{\infty} \Lambda^t \left(\frac{(\tau_t - \bar{\tau})^2}{2} + \kappa^h \left(\frac{h_t}{h_{t-1}} - 1 \right)^2 \right) \right] \tag{24}$$

$$s.t.$$

$$\tau_t \left(w_t n_t + r_t^k k_t \right) + b_t = g_t + \frac{(1+i_{t-1})}{(1+\pi_t)} b_{t-1}^d + \frac{(1+i_{t-1}^*)}{(1+\pi_t)} rer_t b_{t-1}^*$$

Where $\bar{\tau}$ is the steady state of the tax rate, h_t is the share of domestic debt in total debt (b_t), and κ^h is a scalar factor. The left-hand side of the budget constraint depicts the government revenues which include distortionary taxes both from labor and capital gains, and debt borrowing. On the right-hand side, g_t is the government spending, i_{t-1} and i_{t-1}^* are the local and foreign nominal interest on local and foreign debt, respectively. Lastly, π_t is the inflation rate.

Taking the first order condition and solving for the optimal share of domestic debt, h_t, the co-variances with the endogenous and exogenous variables is reached:

$$h_t^* = \frac{\overbrace{\dfrac{cov(g_t,\pi_t) + cov(g_t,q_t)}{d_{t-1}}}^{\text{Spending and inflation}} + \overbrace{var(q_t) + cov(\pi_t,q_t)}^{\text{Pass-through}} - \overbrace{cov(\pi_t,y_t) - cov(q_t,y_t)}^{\text{Exchange rate, inflation, and output}}}{\underbrace{var(\pi_t) + 2cov(\pi,q_t) + var(q_t)}_{\text{Exchange rate and uncertainty}}} \tag{25}$$

The previous expression depicts the implications that co-movements between macroeconomic variables have on the optimal debt composition. In this sense, holding all else constant, an increase in government spending (positive demand shock) is positively correlated with an increase in inflation, which being a factor that reduces the nominal value of the debt, would make it more attractive to boost the share of domestic debt. The variance of the exchange rate and its co-variance with inflation have valuation effects that also affect debt composition. Thus, when there is high exchange rate volatility, there is a greater preference to reduce exposure to increases in the cost of foreign currency debt and therefore to increase the share of domestic debt. Likewise, the pass-through effect between depreciation and inflation would have the same effect.

On the other hand, gains in productivity (supply shock) are negatively correlated with inflation and positively correlated with the exchange rate. Thereby, a supply shock would reduce inflation, so nominal interest rates would probably fall and, as a result, domestic financing would become cheaper. Conversely, the exchange rate would appreciate so that the cost of foreign currency debt would be lower, and domestic debt would be discouraged. The net effect of the supply shock on the share of domestic debt will depend on the magnitude of the response of both inflation and exchange rate. However, in general equilibrium it is important to consider, as this paper does, the effects on the optimal debt composition resulting from the joint interactions of all macroeconomic variables. Hence, it is relevant, for example, to address the response of the central bank and its monetary policy since an increase (decrease) in inflation would tend to raise (reduce) local nominal interest rates, making domestic financing less (more) attractive.

Furthermore, the government expending follows an exogenous autoregressive process as follows:

$$g_t = \rho^g g_{t-1} + (1-\rho^g)\,\bar{g} + \varepsilon_t^g \tag{26}$$

While domestic and foreign debt can be defined as a percentage of the total debt:

$$b_t^d = h_t b_t \tag{27}$$

$$rer_t b_t^* = (1-h_t)\,b_t \tag{28}$$

Now, using the definition of domestic and foreign debt on the budget constraint, the government's total balance (tb_t) is given by the tax revenue net of total primary expenditure and total debt service:

$$tb_t = \tau_t\left(w_t n_t + r_t^k k_t\right) - g_t - \frac{i_{t-1}}{(1+\pi_t)} b_{t-1}^d - \frac{i_{t-1}^*}{(1+\pi_t)} rer_t b_{t-1}^* \tag{29}$$

Nevertheless, the structural balance (sb_t) is defined as the total balance minus the cyclical revenue:

$$sb_t = bt_t - \tilde{\tau}_t \tag{30}$$

$\widetilde{\tau}_t$ is described as total revenues minus long-run structural revenues given by the steady state of labor and capital taxes:

$$\tilde{\tau}_t = \tau_t\left(w_t n_t + r_t^k k_t\right) - \tau_t\left(\bar{w}\bar{n} + \bar{r}^k \bar{k}\right) \tag{31}$$

Additionally, the government follows a fiscal rule based on the structural balance using the tax rate as instrument of policy:

$$\tau_t = \tau_{t-1}^{\rho^\tau}\left[\bar{\tau}\left(\frac{sb_t/y_t}{sb^*/y^*}\right)^{\xi}\right]^{1-\rho^\tau} \tag{32}$$

Note that the accomplishment of the fiscal rule implies that the policy instrument needs to adjust to the objective of structural balance to potential GDP ratio bs^*/y^* with a convergence speed of $1-\rho^\tau$.

Finally, the monetary policy rule responds to deviations of inflation from its target:

$$i_t = \phi\, i_{t-1} + (1-\phi)\left[\bar{i}_t + \gamma(\pi_t - \bar{\pi})\right] + \varepsilon_t^i \tag{33}$$

Where $\bar{i}_t$ is the long-run nominal interest rate, $\bar{\pi}$ is the inflation target, and ε_t^i is a stochastic component.

3.4 Open economy

Following Schmitt-Grohé & Uribe, 2003, the cost of debt in foreign currency is given by the foreign nominal interest rate (i_t^f) scaled by an exogenous risk component ($risk_t$) that weights the deviation of the debt-to-GDP ratio from its steady-state level:

$$(1 + i_t^*) = \left(1 + i_t^f\right) \exp\left[\gamma^r \left(\frac{b_t}{y_t} - \frac{\bar{b}}{\bar{y}}\right)\right] risk_t \tag{34}$$

The risk component is defined as an autoregressive process which tends towards its long-term level ($\overline{risk}$):

$$risk_t = \rho^{rk} risk_{t-1} + \left(1 - \rho^{rk}\right) \overline{risk} + \varepsilon_t^{rk} \tag{35}$$

Similarly, the foreign interest rate follows an exogenous process with the same features, with $\bar{i}_t^f$ its steady state value:

$$\left(1 + i_t^f\right) = \rho^{i^f} \left(1 + i_{t-1}^f\right) + \left(1 - \rho^{i^f}\right) \left(1 + \bar{i}_t^f\right) + \varepsilon_t^{i^f} \tag{36}$$

In which $(1 - \rho^{rk})$ and $(1 - \rho^{i^f})$ denote the speed of convergence of both variables to their long-run levels, respectively.

On the other hand, the exports of domestic economy are given by:

$$xt_t = \overline{xt} \left(\frac{p_t^d}{e_t p_t^*}\right)^{-\chi} y_t^* \tag{37}$$

Where $\overline{xt}$ is a scaling factor of the external demand for domestic goods, which in turn considers the relative prices between local and foreign goods. As well, the external demand (y_t^*) is an autoregressive process such as:

$$y_t^* = \rho^* y_{t-1}^* + (1 - \rho^*)\bar{y}^* + \epsilon_t^* \tag{38}$$

Finally, the trade balance is defined as the difference between the economy's exports and the value of the products imported:

$$tb_t = xt_t - p_t^m c_t^m \tag{39}$$

4 Results

4.1 Calibration

The model is calibrated for Colombia, Chile and Mexico. For all countries, the intertemporal discount factor of households is β=0.99, the labor scale parameter is η=0.29, the Frisch elasticity of labor $1/\nu$=1.54, the complementary/substitute parameter of government spending α_g=0.3, the share of domestic goods consumption ψ_c=0.77, the elasticity substitution domestic/foreign goods ω_c=3, the elasticity of substitution θ=20, the depreciation rate of capital δ=0.025, adjustment cost of capital κ=1, the gap of structural deficit ξ=0.3, the elasticity of terms of trade χ=0.05, sensibility of inflation gap γ=1.5, the scale factor of risk γ^{risk}=0.0025.

Additionally, the persistence parameters of the different types of shocks are: productivity ρ_z=0.55, domestic nominal interest rate ϕ_i=0.3, government spending ρ_g=0.74, fiscal rule ρ^{τ}=0.85, spread ρ_{rk}=0.75, risk-free rate ρ_{p^*}=0.75, external demand ρ_{y^*}=0.75. Other parameters that change by country are depicted in Table 2.

Table 2: Calibrated Parameters and Steady States by Country

	Symbol	Colombia	Chile	Mexico
Parameters				
Adjustment cost of debt	κ_h	0.0038	0.0040	0.0035
Scale factor exports	$\overline{xt}$	0.05	0.09	0.048
Steady state				
Government spending (% of GDP)	$\overline{g}$	17	21	18.5

Source: Ministry of Finance and authors' calculations.

A summary of the response of macroeconomic variables from a positive transitory government spending shock of 1% and a positive monetary shock are described in Figure 2 and 3. In the first case, on impact the response on output describes the embedded crowding-out effect of government spending on the private sector consumption that induces lower demand of goods, higher investment and a subsequent positive adjustment in production. Because there is a private consumption leisure trade-off condition, the shock requires households to increase the supply of labor to smooth consumption reducing the cost of this input for production. This lower cost of labor, induces higher demand of labor as well as higher investment and capital accumulation subject to a new demand of goods.

This increases product on impact where there is a positive deviation of output from the steady state of 0.03% in the first period that turns negative thereafter to almost 0.04% and slowly decays. The increase of demand of labor increases the marginal cost of firms and thus the inflation rate. Note that, the share of firms that can adjust price instantaneously act accordingly to hold the profit maximization condition. On the other hand, the demand shock produced by the increase in government spending induces nominal exchange rate depreciation, contributing to higher inflation through imported goods. Likewise, the increase in prices implies inflation to deviate positively around 0.03% from the steady state. The overall inflation increase pushes the domestic nominal interest rate upwards by 0.04% through the monetary policy reaction function and decays by the 10th period.

The increase in labor, increases fiscal revenues as much as 1.2% through higher labor income tax in the first period and rapidly decays. The increase of fiscal revenues permits the financing of government spending without an initial issuance of debt (and even decreases for the case of Chile). Nonetheless, as government revenues decay, the public debt increases after 10 periods around 0.15% for Colombia and Mexico and 0.2% in Chile. In consequence, the deviation of the public debt from its steady-state level increases the nominal foreign interest rate in parallel with debt dynamics. Finally, the share of local currency debt increases with the combination of the previous factors. The depreciation of the nominal exchange rate and the foreign interest rate offsets the increase in inflation and the domestic interest rate.

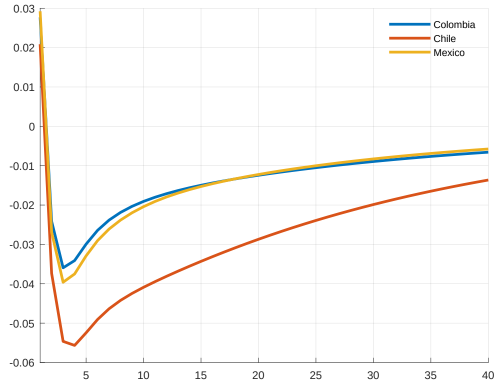
4.2 Optimal debt level

To derive the optimal share of local currency debt we estimate the model using Bayesian methods with quarterly data from 2006Q1 to 2020Q4. The purpose of estimation is to make a counterfactual analysis by comparing the optimal share level of debt estimated by the model versus the observed path. Table 3 shows priors and posteriors found from parameter estimation for four Markov Chains Monte Carlo (MCMC) with 10000 extraction in each chain.

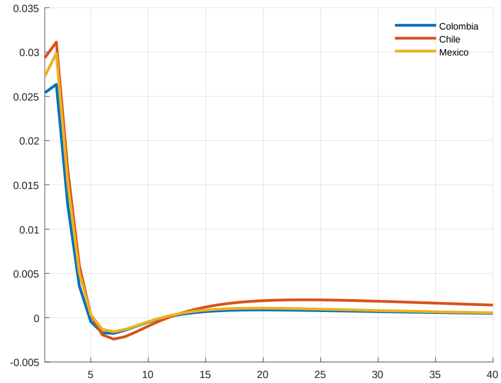
Chile: Figure 4a before the commodity price shock, the optimal share of local currency debt pointed around 78% and the observed level was close to 84% on average. Both oil and copper prices dropped in late 2014, but the latter to a lesser extent. Therefore, Chile's terms of trade did not deteriorate significantly. The nominal exchange rate depreciated albeit at similar levels to those experienced in 2008. Despite the depreciation, domestic prices dropped, pushing the central bank to reduce interest rates further. These factors favored a stable path of optimal debt in local currency around 80% that resembles somewhat the behavior of the observed debt share in Chile. The dynamics in Chile were different from that of Colombia and Mexico for several reasons. The fiscal space was favorable before the copper price shock and acted as a buffer to respond to the shock as well. Low levels of budget deficit, financing need and low levels of debt mixed with stable inflation dynamics and full flexibility of the exchange rate to absorb shocks reduced the need for external financing. However, since the copper price drop there is a moderate trend towards foreign debt that increased significantly during the COVID-19 pandemic.

Colombia: Figure 4b depicts the optimal share of local currency where in two key periods the optimal share and the observed differ widely. Between 2011 and the beginning of 2014, the country risk perception was favorable and external interest rates dropped. Likewise, ample global liquidity pushed inflows of capital to the country and contributed to the appreciation of the nominal exchange rate. In this same period, inflation dynamics were broadly in line with the central bank's target; thus local rates where reduced albeit to a lesser extent than the external rates. This mix leads to a lower optimal share of local currency debt compared to the observed

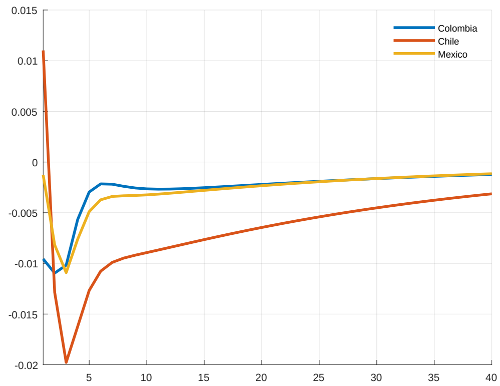
Figure 2: Government spending 1% shock (+)



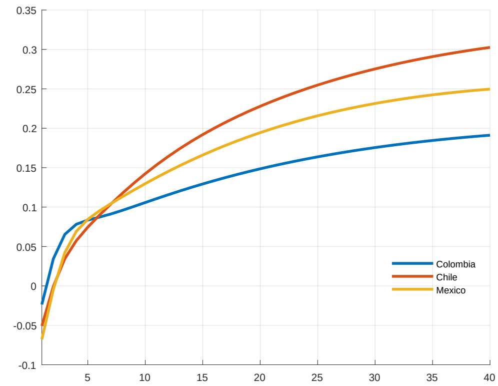
(a) Output



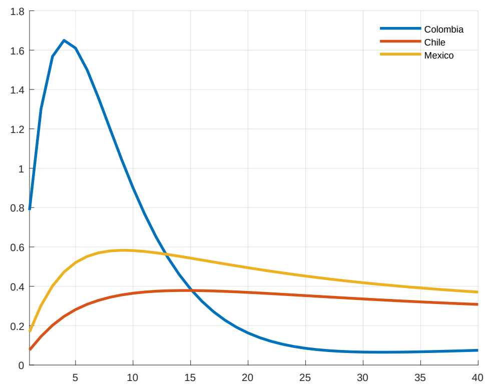
(b) Inflation



(c) Total balance



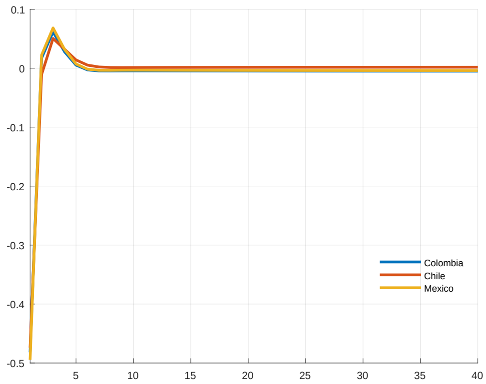
(d) Public debt



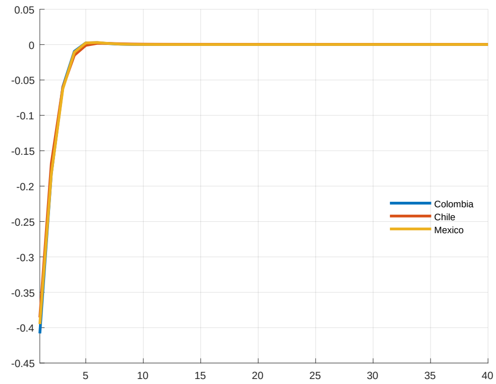
(e) Share local currency debt

Source: Authors' calculations.

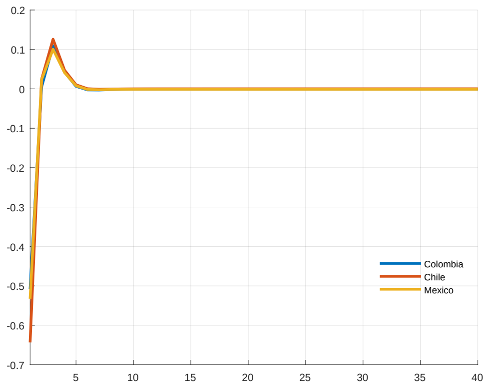
Figure 3: Monetary 1% shock (+)



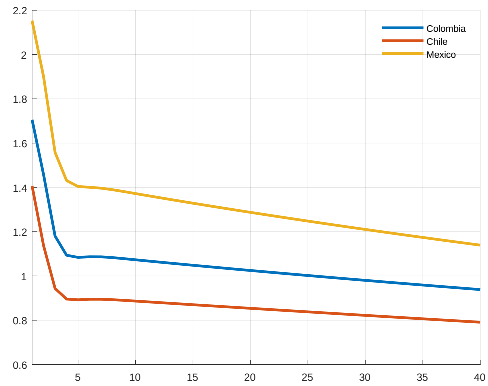
(a) Output



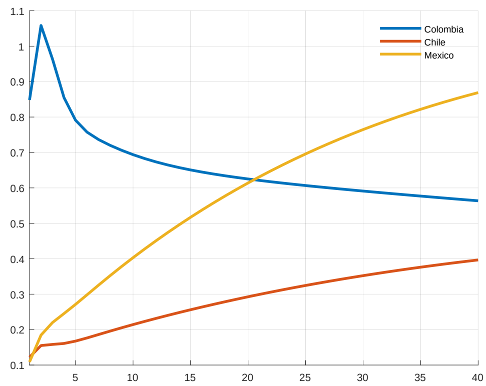
(b) Inflation



(c) Total balance



(d) Public debt



(e) Share local currency debt

Source: Authors' calculations.

Table 3: Prior and posterior of estimated parameters

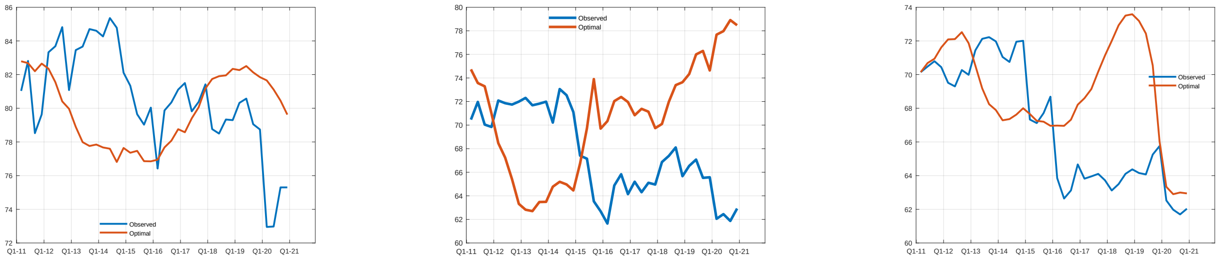
Parameters	Prior mean	Post mean	HPD inf	HPD sup	Prior	Post. deviation
Colombia						
κ	0.800	0.0928	0.0210	0.1621	gamma	0.3000
γ_{risk}	0.005	0.0049	0.0034	0.0064	gamma	0.0010
ρ_{ystar}	0.700	0.7593	0.6689	0.8534	beta	0.1000
ρ_g	0.700	0.1438	0.1031	0.1901	beta	0.1000
ρ_z	0.700	0.5263	0.3992	0.6483	beta	0.1000
ρ_{spread}	0.700	0.6131	0.5417	0.6961	beta	0.1000
Chile						
κ	1.000	1.0548	0.3660	1.5795	gamma	0.3000
ρ_{ystar}	0.700	0.7959	0.6904	0.8930	beta	0.1500
ρ_g	0.700	0.8276	0.7605	0.8940	beta	0.1500
ρ_z	0.700	0.9231	0.9133	0.9325	beta	0.1500
ρ_{spread}	0.700	0.4283	0.3527	0.5154	beta	0.1500
Mexico						
κ	1.500	0.8528	0.4698	1.2417	gamma	0.3000
ρ_{ystar}	0.700	0.7887	0.6822	0.9091	beta	0.1500
ρ_g	0.600	0.7894	0.7020	0.8683	beta	0.1500
ρ_z	0.700	0.9477	0.9424	0.9527	beta	0.1500
ρ_{spread}	0.710	0.2063	0.1164	0.3032	beta	0.1500

Source: Authors' calculations.

share. Furthermore, after the commodities price shock the nominal exchange rate depreciated substantially and inflation expectations rose. The central bank reacted by increasing interest rates. However, the combination of nominal exchange rate depreciation and the increase of risk perception led to an increase in the optimal level of local currency share. In this period the deviation of observed share of local currency debt from the optimal level reached levels of 10%. In the COVID-19 period, the optimal and observed share of local currency continued to differ. The drop in growth and lower local interest rates implied a bigger optimal share of local currency debt; however, this was not the observed case. The reduction of interest rates abroad as well as subdued inflation favored foreign debt.

Mexico: Figure 4c depicts the optimal share in local currency for Mexico and describes similar behavior to the other countries before the price shock; after they differ widely. Prior to the oil price shock, exchange rate depreciation was contained, inflation was in line with the target, and monetary policy was supportive to growth and stable prices. Observed share of local debt was somewhat on optimal levels with a difference of 0.4 percentage points. However, the drop in oil prices had a negative impact on the terms of trade though not in the same magnitude as Colombia. The nominal exchange rate depreciation did not overshoot and inflation dynamics

Figure 4: Share of local public debt



(a) Chile (b) Colombia (c) Mexico

Source: International Monetary Fund, national sources, and authors' calculations.

increased with a strong lag. This increase in inflation favored an optimal level of local currency debt but the observed path shows a steady and lower share of debt.

5 Final Remarks

For the past two decades there has been an increasing trend in sovereign debt in some EMs at different pace. For some countries in Latin America this dynamics has been challenging because the level, the share of foreign currency and the cost of debt have increased considerably even in the presence of fiscal rules. This upward trend of public debt was reinforced with the recent pandemic. Indeed, in a simple debt dynamics framework the interest rate payments and nominal exchange rate depreciation are key underlying determinants of debt growth and highlights the relevance of debt management policy. Proper management of debt contributes to tax and government consumption smoothing that is necessary to support macroeconomic turbulence in episodes of economic downturn.

The model captures the relevance of debt management policy as its highlights the trade-off of minimizing budget risk and minimizing debt cost in an environment of fiscal rules. For a small open economy oriented to commodity exports, such as those in Chile, Colombia and Mexico the importance of the decision to use foreign currency as a hedging tool becomes relevant as the cost of debt rises even in a fiscal rule environment. This increase in cost of debt might reduce the fiscal policy option to smooth macroeconomic shocks and comply with the fiscal rule.

The results show that in Chile, Colombia and Mexico there is room to design a debt structure by currency composition to minimize tax distortions both in pre-pandemic and during pandemic periods. The gap between the optimal level of debt can be as wide as 10 percentage points in some cases. This directly suggests a space to reduce financing cost and overall budget deficit. The average deviation from optimal share of local currency between 2011 and 2020 is 4% below optimal for Colombia, 1% above optimal in Chile, and 2% below optimal in Mexico. These deviations vary around two key macroeconomic events: the commodity price shock and the recent pandemic. Observed foreign currency debt increases in the economic downturn, departs substantially from optimal levels, and illustrates difficulty to return to optimal.

References

Arslanalp, M. S., & Tsuda, M. T. 2014. Tracking global demand for emerging market sovereign debt. *IMF Working Papers*, *2014*(039).

Barreix, A. D., Corrales, L. F., Benitez, J. C., Garcimartín, C., Ardanaz, M., Díaz, S., ... Escobar Arango, A. 2019. *Reglas fiscales resilientes en América Latina* (Vol. 767). Inter-American Development Bank.

Barro, R. J., & Gordon, D. B. 1983. Rules, discretion and reputation in a model of monetary policy. *Journal of Monetary Economics*, *12*(1), 101–121.

Benito, B., Bastida, F., & Vicente, C. 2013. Creating room for manoeuvre: a strategy to generate political budget cycles under fiscal rules. *Kyklos*, *66*(4), 467-496.

Bohn, H. 1990. Tax smoothing with financial instruments. *The American Economic Review*, *80*(5), 1217–1230.

Claessens, S., Klingebiel, D., & Schmukler, S. L. 2007. Government bonds in domestic and foreign currency: The role of institutional and macroeconomic factors. *Review of International Economics*, *15*(2), 370–413.

Du, W., Pflueger, C. E., & Schreger, J. 2020. Sovereign debt portfolios, bond risks, and the credibility of monetary policy. *The Journal of Finance*, *75*(6), 3097–3138.

Du, W., & Schreger, J. 2016. Local currency sovereign risk. *The Journal of Finance*, *71*(3), 1027–1070.

Engel, C., & Park, J. 2022. Debauchery and Original Sin: The Currency Composition of Sovereign Debt. *Journal of the European Economic Association*, *20*(3), 1095-1144.

Fève, P., Matheron, J., & Sahuc, J.-G. 2013. A pitfall with estimated DSGE-based government spending multipliers. *American Economic Journal: Macroeconomics*, *5*(4), 141–78.

Gomez-Gonzalez, P. 2019. Inflation-linked public debt in emerging economies. *Journal of International Money and Finance*, *93*, 313–334.

Kydland, F. E., & Prescott, E. C. 1977. Rules rather than discretion: The inconsistency of optimal plans. *Journal of Political Economy*, *85*(3), 473–491.

Li, Y., & Panizza, U. 2013, 10. The economic rationale for the principles on promoting responsible sovereign lending and borrowing. In *Sovereign financing and international law: The unctad principles on responsible sovereign lending and borrowing.* Oxford University Press.

Missale, A. 1997. Managing the public debt: The optimal taxation approach. *Journal of Economic Surveys*, *11*(3), 235–265.

Miyajima, K., Mohanty, M., & Chan, T. 2015. Emerging market local currency bonds: Diversification and stability. *Emerging Markets Review*, *22*, 126-139.

Neyapti, B. 2013. Fiscal decentralization, fiscal rules and fiscal discipline. *Economics Letters*, *121*(3), 528–532.

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

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

Weber, C. E. 2005. Edgeworth on Complementarity, or Edgeworth, Auspitz-Lieben, and Pareto De-Homogenized. *History of Political Economy*, *37*(2), 293-307.