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Rodrigo Vergara*

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*rvergara@faceapuc.cl

INDEX

DEBT VALUATION EFFECTS WHEN THERE IS FOREIGN CURRENCY-DENOMINATED DEBT*

Claudia Martínez[a]

Rodrigo Vergara[b]

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Abstract

This paper discusses the way in which the existence of debt denominated in both domestic and foreign currency affects debt-sustainability analyses. Ignoring valuation issues can lead to misleading conclusions regarding fiscal sustainability. We show that a devaluation of the domestic currency can significantly change the path of a sustainable fiscal policy. In our model, the adjustment not only comes through the change in the value of the foreign currency-denominated public debt, but also though the effects on the interest rate and growth. We find that the required fiscal adjustment to achieve fiscal sustainability after a devaluation increases with the size of the devaluation, the length of the adjustment period, the effect on interest rates and growth, and the share of public debt that is denominated in foreign currency.

Keywords: public debt, valuation effects, debt management

JEL Classification: F34, H63, H87

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[a]Claudia Martínez
Economics Department. Pontificia Universidad Católica de Chile. Casilla 76, Correo 17, Santiago, Chile. (cmartinezc@uc.cl). Tel.: (562) 686 4326. . Fax: (562) 553 6472.
[b]Rodrigo Vergara (Corresponding author)
Economics Department. Pontificia Universidad Católica de Chile. Casilla 76, Correo 17, Santiago, Chile. (rvergara@faceapuc.cl). Tel.: (562) 686 4326. . Fax: (562) 553 6472.

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1. Introduction

This paper discusses the way in which the existence of debt denominated in both domestic and foreign currency affects debt-sustainability analyses. We show that a devaluation of the domestic currency can significantly change the path of a sustainable fiscal policy.

This is important, for instance, to poor countries. Most of the public debt of these countries is dollar-denominated. A devaluation not only increases the debt ratios. It will most likely also affect the interest rate that the country can negotiate on international markets, hence increasing the debt burden. It will likely also have effects on growth in the short term, which can also affect the sustainable fiscal path.

Policy decisions must take this factor into account because LDCs frequently face terms of trade or other shocks that require a real devaluation. A possibility, suggested by Hausmann (2003),[1] would be to issue domestic currency-denominated debt. But it is well known that this is a limited possibility for many developing countries as the domestic financial system is not well developed. In several cases, it is not a matter of insufficient domestic savings but rather a history of expropriations (either directly or by unexpected high inflation). This translates into a high cost of domestic public debt.[2]

The paper is organized as follows. In section 2, we motivate the issue by discussing the concept of sustainability, the policy debate on this subject, and by reviewing the recent literature. In section 3, we present the sustainability model, which differs from early literature by including the valuation effects. In section 4, we estimate the key parameters of the model. With this estimation and other assumptions that are common to developing countries,[3] we perform, in Section 5, some simulations to determine the sustainable path of the fiscal balance after a significant devaluation of the domestic currency. We find that the effects on this sustainable path can be quite significant. Section 5 concludes.

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[1] See also Hausmann and Panizza (2003) and Eichengreen, Hausmann and Panizza (2003).
[2] This assumes that expropriations are more likely to occur with domestic rather than with foreign debt.
[3] See Edwards and Vergara (op.cit.) for a detailed discussion of some of these parameters.

2. Fiscal sustainability and valuation problems: a discussion

An economy is said to have achieved fiscal sustainability when the ratio of public sector debt to GDP is stationary, and consistent with the overall demand–both domestic and foreign–for government securities.[4] An important by-product of public sector sustainability analyses is the computation of the public sector's *primary balance* compatible with a sustainable and stable debt to GDP ratio.[5] This "sustainable primary balance" has become an increasingly important variable in macroeconomic analyses and is now routinely included as a disbursement condition in IMF programs. The World Bank and the IMF have analyzed the external debt sustainability issue using a "present value constraint" approach.[6] This approach consists of analyzing whether, once debt is forgiven (for instance for Heavily Indebted Poor Countries), the net present value of the country's external debt stabilizes at its "steady state" level relative to GDP.[7] A characteristic of the World Bank-IMF approach is that it implicitly assumes that if the country implements an appropriate set of economic reforms, the debt-to-GDP ratio achieved immediately after debt relief will be sustainable in the longer run. Hence, it does not consider possible valuation problems in the future. This paper goes further than previous work by the authors and explicitly discusses the way in which real exchange rate changes, more specifically, real exchange rate devaluations, affect fiscal sustainability.

This paper is also related to recent literature that emphasizes the problems for macroeconomic policy in emerging economies derived from large currency mismatches. Eichengreen and Hausmann (1999) refer to the situation in which countries cannot use the domestic currency to borrow abroad as the "original sin" since it implies that the country becomes extremely vulnerable to any shock that causes a change in the real exchange rate.

Calvo, Izquierdo and Talvi (2002) consider the effects of a real 50% depreciation of the domestic currency on fiscal sustainability in different Latin American countries, assuming that interest rates and GDP growth remain unchanged. For the case of Argentina, these authors find that the 50% depreciation requires an adjustment of 0.7% to

[4] Naturally, the debt ratio may be calculated relative to alternative benchmarks. On sustainability analyses see, for example, Milesi-Ferreti and Razin (1996, 2000) and Edwards (2002).

[5] The primary balance is defined as the nominal balance, excluding interest payments.

[6] See, for example, World Bank and IMF (2002), Lachler (2001).

[7] See Cuddington (1995).

the GDP in the primary balance so as to keep the ratio of debt to GDP constant. In our analysis, we assume that both interest rates and GDP are affected, at least in the short run, and we also introduce dynamic aspects, such as countries having some time to adjust to their sustainable debt level after the devaluation.

Calvo and Reinhardt (2002) argue that devaluations are more contractionary in developing countries than in industrial countries. The basic explanation is that the former have larger currency mismatches than the latter. These currency mismatches give rise to what they call the "fear of floating." Hausmann et al. (2001) argue that the greater the dependence on foreign currency borrowing, the greater the "fear of floating" on the part of developing economies. They show that the currency mismatches explain the cross-country differences in the fear of floating better than the cross-country differences in the pass-through coefficient.

3. The model

Total public debt (measured in domestic currency) is calculated as:

(1) $D_t = P_t + e_t F_t$

D_t is total debt, P_t is domestic currency-denominated debt, F_t is dollar-denominated debt, and e_t is the nominal exchange rate (domestic currency per dollar). Subscript t denotes time.

We assume that this country starts from a position of fiscal sustainability[8] in the sense that its total public debt as a ratio of GDP (D_t/Y_t) is consistent with the demand for government debt.

From (1) it follows that,

(2) $\Delta D_t = \{\Delta P_t + e_t \Delta F_t\} + F_t \Delta e_t$

[8] For instance, a HIPC country after the completion point.

The first term on the right-hand side $\{\Delta P_t + e_t \ \Delta F_t\}$ represents new debt being issued, and in that regard, it captures "fresh" resources. The second term $\{F_t \ \Delta e_t\}$ is the *valuation effect*. Equation (2) clearly shows that the total debt measured in domestic currency can increase for two reasons: new debt may be issued or the local currency-value of the old debt may increase due to a nominal devaluation. Naturally, there may be a combination of these two factors.

According to the public sector budget constraint, net new debt issued- in domestic and foreign currency--has to be equal to the gap between expenditures and revenues. Expenditures can be broken down in two components: primary expenditures and interest payments. Revenues, in turn, are equal to seigniorage (S_t) and other revenues. Thus, the public sector budget constraint may be written as follows (where ΔD_t^N is new debt issued and corresponds to the term $\{\Delta P_t + e_t \ \Delta F_t\}$ in equation (2)):

(3) $$\Delta D_t^N = -pb_t + i_t P_t + i_t^{FC} F_t - S_t$$

where pb_t is the primary balance, defined as non-seigniorage revenues minus primary expenditures, i_t is the interest rate on domestic currency-denominated debt, and i_t^{FC} is the interest rate on foreign currency-denominated debt.

A key variable in any sustainability analysis is the evolution of the debt-to-GDP ratio over time. To the extent that both variables–debt and GDP–are measured in the same currency, tracing the evolution of the ratio is easy. Things are a bit more complicated when the two variables in the ratio are denominated in different currencies or, more specifically, when part of the debt is denominated in foreign currency.

Let δ represent the debt-to-GDP ratio:

(4) $$\delta_t = \frac{D_t}{Y_t}$$

Where both variables are measured in current local currency and D_t comes from equation (1).

It follows from (4), (1) and (2) and after some math that:

(5) $$\Delta\delta_t = \left\{ \frac{\Delta P_t}{D_t} + \frac{e_t \Delta F_t}{D_t} + \frac{F_t \Delta e_t}{D_t} - (g_t + \pi_t) \right\} \delta_t$$

Where g_t is real GDP growth and π_t is the domestic rate of inflation. If there is no foreign currency-denominated debt, then $F_t = 0$ and (5) collapses to the familiar expression for public sector debt sustainability.[9]

If, however, some public sector debt is denominated in foreign currency, the traditional analysis will be misleading. In this case, using equation (3) on the public sector budget constraint and some algebra, we obtain the expression for the primary balance consistent with a steady-state fiscal sustainability (i.e. $\Delta\delta_t = 0$):

(3) in (5):

$$\Delta\delta_t = \frac{-pb_t + i_t P_t + i_t^{FC} e_t F_t - S_t}{Y_t} + \frac{F_t \Delta e_t}{Y_t} - (g_t + \pi_t)\delta_t$$

Note that in steady state $\Delta\delta_t = 0$.

Using the Fisher equation $i_t = r_t + \pi_t$; $i_t^{FC} = r_t^{FC} + \pi_t^{*}$, and the real exchange rate definition:

$$\hat{RER}_t = \frac{\Delta e_t}{e_t} + \pi_t^{*} - \pi_t \quad ==> \frac{\Delta e_t}{e_t} = \hat{RER}_t - \pi_t^{*} + \pi_{it}$$

The following expression is obtained for the primary budget balance:

(6) $$\frac{pb_t}{Y_t} = -\Delta\delta_t - \frac{S_t}{Y_t} + \frac{P_t}{Y_t}(r_t - g_t) + \frac{e_t F_t}{Y_t}(r_t^{FC} - g_t) + \frac{e_t F_t}{Y_t}\hat{RER}_t$$

[9] In a steady state, where $\Delta\delta_t = 0$, then $\Delta P_t/P_t = \Delta D_t/D_t = g_t + \pi_t$, or $\Delta D_t/Y_t = D_t/Y_t\,(g_t + \pi_t)$. This implies that to maintain the ratio of public debt to GDP constant, the budget deficit has to be equal to the debt-to-GDP ratio times the nominal GDP growth rate.

In deriving this expression, we have also used the fact that the nominal GDP growth rate is equal to real growth (g_t) and inflation (π_t). r_t is the real interest rate on domestic currency-denominated debt and r_t^{FC} the real interest rate on foreign currency-denominated debt. The last term on the right-hand side is the "correction factor" that arises from the existence of foreign currency-denominated debt. RER_t is the real exchange rate and the hat stands for the percentage change.

Notice that ignoring this "correction factor" will result in a miscalculation of the primary deficit consistent with a stable debt-to-GDP ratio. In particular, if the country experiences a real devaluation–that is, if ($\Delta RER_t/RER_t$) > 0–, ignoring the "correction factor" will result in an underestimation of the primary balance consistent with sustainability.

The case where there is a Balassa-Samuelson effect in which the currency exhibits a real appreciation over time can be thought of as leading to a larger sustainable primary deficit (see equation 6) since this implies that the value of the foreign debt as a percentage of GDP is declining over time due to this effect. This, however, does not invalidate our concern regarding the dramatic valuation effects that can take place if there is a considerable devaluation.

Assuming that δ^* is the sustainable public-debt-to-GDP ratio in the sense that it is consistent with the demand for that debt, then if $\delta_t < \delta^*$, the country will be able to sustain smaller primary balances than those of a steady state for a while. In equation (6) $\Delta\delta_t$ is positive (hence the primary balance smaller) in the sense that the debt to GDP ratio can increase and still be consistent with debt sustainability. The inverse occurs if $\delta_t > \delta^*$.

We assume that the uncovered real interest rate parity holds:

$$\text{(7)} \qquad r_t = r_t^* + E(\hat{RER}_t) + \rho_t = r_t^{FC}$$

where ρ_t is the country risk premium and r_t^* is the (exogenously given) risk-free world interest rate. Additionally, we assume that $E(\hat{RER}_t) = 0$.

On the other hand, as in Edwards (1986) and Min (1998), we assume that the country risk premium is a function of the level of public debt and a set of economic variables (X_t). The larger the public debt, the higher the risk premium. Hence:

(8) $\rho_t = \rho(\delta_t, X_t)$ with $\partial\rho_t / \partial\delta_t > 0$

We also assume that after a devaluation occurs, the debt holders (actual and potential) do not necessarily require the country to return its initial position immediately. They understand that there are valuation effects. Hence, they give some time $\bar{t}$ to the country to adjust and return to δ*. This time $\bar{t}$ will depend on the track record of the country and on the credibility of its adjustment program.

Let us call the accepted level of public debt (as a ratio of GDP) in the years after a devaluation as $\bar{\delta}_t$. The behavior of $\bar{\delta}_t$ is represented by:

(9) $\bar{\delta}_t = \delta^* + (\delta_0 - \delta^*)(1 - \gamma t)$ for t = 1,2,….. $\bar{t}$

where $\gamma = \frac{1}{\bar{t}}$

δ_0 represents the actual level of public debt just after the devaluation. In other words,

(10) $\delta_0 = \delta^* + \frac{F_t \Delta E_t}{Y_t}$

Expression (9) tells that as t approaches $\bar{t}$, the level of accepted public debt approaches the steady-state level δ*. On the one extreme, if the market give the country just one period to adjust to δ*, then $\bar{\delta}_t = \delta^*$. This means that the primary balance will have to increase as much as necessary so that the ratio of public debt to GDP remains unchanged at level δ*. On the other extreme, if the market gives the country infinite time to adjust ($\bar{t} = \infty$), then $\bar{\delta}_t = \delta_0$. This means that the new equilibrium debt-to-GDP ratio becomes δ_0 rather than δ^*.

Finally, we assume that when public debt is above its sustainable level, GDP growth is below its potential, the reasons being the higher interest rate discussed above and also the increased uncertainty derived form the fact that taxes or seigniorage might be increased to finance the larger primary deficit. The larger the gap between sustainable and actual debt, the greater the impact on growth. This can be expressed as:

$$(11)\quad g = \begin{cases} g_t^* & \text{if} \quad \delta_t \leq \delta^* \\ g_t^* - \beta(\delta_t - \delta^*) & \text{if} \quad \delta_t > \delta^* \end{cases}$$

where g* is the potential GDP rate of growth.

4. Estimations

In this section, we are interested in estimating the effect of public debt on the interest rate of that debt (equations 7 and 8), the dynamics of the debt when there is a shock to the real exchange rate (equation 9 and 10), and the impact of debt on growth (equation 11).

Our estimations consider five Latin American countries: Brazil, Chile, Colombia, Mexico and Peru.[10] We use quarterly data for the period 1999:I – 2007:IV. The variables include the country risk as measured by the quarterly average of the EMBI Plus index (ρ_t).[11] The data on external public debt as a percentage of GDP was obtained from the World Bank. For the real exchange rate, we use the traditional measure $\left(RER_t = \frac{E_t P_t^*}{P_t}\right)$

[10] The sample is limited by the availability of country risk data for Latin American countries.
[11] The EMBI Plus measures the interest rate differential between the dollar bonds issued by governments and the U.S. Treasury bonds. The source is www.valorfuturo.cl.

where P_t* is the dollar-denominated CPI of the main trading partners, E is the nominal exchange rate (local currency per dollar), and P is the domestic CPI. All these data plus the GDP growth data were obtained from the central banks of the countries considered in the study.[12]

Public debt and interest rates

We now proceed to estimate the effect of a change in public debt on the interest rate of that debt. Because there is no total public debt quarterly data available for all countries considered, we do our estimations using only foreign public debt.[13] Our dependent variable is the risk premium (see equations 7 and 8), that is, we want to estimate the effect of a change in the public debt on the risk premium paid on that debt.

We estimate the following panel:

$$(12) \quad \rho_{it} = \alpha_1 + \alpha_2 \rho_{it-1} + \alpha_3 \left(\frac{EPD}{GDP}\right)_{it} + \alpha_4 RER_{it} + \alpha_5 g_{it} + \lambda_t + \mu_i + \xi_{it}$$

Where subscript i denotes the country (i = 1,2….5) and subscript t denotes the quarter :

- $\left(\frac{EPD}{GDP}\right)_{it}$ is the ratio of public foreign debt to GDP. As we mentioned above, it is expected that the greater the public debt, the higher the risk premium.
- RER_{it} is the real exchange rate index. Like in Edwards (1986) and Min (1998), we analyze whether a less competitive real exchange rate (appreciation) can adversely affect the risk premium. According to Cline (1983), real appreciations in LDCs played a major role in the overborrowing process.
- g_{it} is the rate of growth of GDP. We expect that a higher GDP growth will reduce country risk.

[12] The unit root tests of our variables reject the null hypothesis that variables are order-1 integrated.
[13] For the five countries considered in this paper, foreign public debt represents about 50% of total public debt. For less developed countries, the share of foreign debt is even higher.

-Finally, λ_t is a temporary fixed effect, μ_i is a country-specific fixed effect, ξ_{it} is an iid $(0,\sigma_\xi^2)$ distributed-error term.

We first estimated equation (12) using a static GLS fixed-effect method. The Hausmann test rejects the null hypothesis of no correlations between the fixed effects and the explanatory variables, thus validating the estimation through fixed effects. However, considering both the dynamic structure of the model and the potential endogeneity of the explanatory variables, we proceeded to estimate it by the Arellano and Bond (1991) methodology.

The results are presented in Table 1. The first regression shows the results of the fixed-effect estimation. The effect of the debt on the risk premium (and hence interest rate) is positive and statistically significant. The coefficient shows that a 1 percentage point increase in the debt-to-GDP ratio (say from 30% to 31%) produces an increase in the interest rate of 18 basis points (say from 5% to 5.18%). Regressions 2-4 show the results of the dynamic estimation using the Arellano and Bond methodology. The results are consistent with those found in regression 1 in the sense that the coefficient of the debt variable is positive and statistically significant and the magnitude of the short-term effect is about the same. However we are able, with the dynamic specification, to obtain long-term effects. Note that the coefficient of the lagged dependent variable is positive and statistically significant, indicating a persistence in the effect on the risk premium. In particular, the results show that in the long term, there is an effect of 30 basis points in the interest rate as the ratio of public debt to GDP increases by one percentage point.

Both the Sargan test and the second-order residual serial correlation tests confirm the fact that the errors are serially uncorrelated and the validity of the instrumental variables.

Table 1

Estimates using Fixed Effects model and Arellano-Bond model

Dependent Variable: Interest rate spread (ρt)

	Equation 1	Equation 2	Equation 3	Equation 4
ρ_{t-1}	-	0.354 (0.064)***	0.241 (0.168)	0.282 (0.131)**
External Public Debt/GDP_t	0.183 (0.028)***	0.184 (0.044)***	0.167 (0.028)***	0.167 (0.025)***
RER_t	0.06600 (0.009)***	-	0.0420 (0.018)**	0.0350 (0.012)***
GDP growth rate $_t$	-0.083 (0.053)	-	-	0.015 (0.099)
Time Effect	YES	YES	YES	YES
R2 within	0.8190	-	-	-
R2 between	0.8318	-	-	-
R2 overall	0.7826	-	-	-
Sargan Test (p-value)	-	1.00	1.00	1.00
Serial Correlation order 1	-	0.0740	0.1411	0.0508
Serial Correlation order 2	-	0.2835	0.2343	0.2443
Observations	155	148	148	148
Groups	5	5	5	5

Robust standard errors in parenthesis

* significant at 10%; ** significant at 5%; *** significant at 1%

The dynamics of public debt

The second step in our analysis is to study the dynamics of public debt when the exchange rate changes (equations 9 and 10). To address this issue, we use vector autoregressions (VAR) to analyze the dynamic impact on public debt in each country of a random disturbance in the real exchange rate.

Let X_t be the vector of endogenous variables. It would be written in reduced form as follows for the VAR system:

$$X_t = A(L)X_{t-1} + U_t$$

where $X_t = \left[\frac{EPD}{GDP_t}, RER_t, \rho_t, g_t\right]$ and U_t is a reduced residuals vector defined as:

$$U_t = \left[u_t^{\frac{EPD}{GDP}}, u_t^{RER}, u_t^{\rho}, u_t^{g}\right]$$

The equations include a lag, established using Akaike's criteria.

The reduced residuals (U_t) and, more specifically, the residuals of the foreign public debt-to-GDP ratio $\left(u_t^{\frac{EPD}{GDP}}\right)$, can also be determined as: (1) a linear combination of the response of the foreign public debt-to-GDP ratio when there are unexpected shocks in the other variables, (2) the discretionary response of the policy-maker to changes in the variables[14] and (3) the random shocks of foreign debt.[15]

As mentioned earlier, our analysis is concentrated on the response of the foreign public debt-to-GDP ratio to an unexpected shock in the real exchange rate. We are specifically looking to estimate the time $(\bar{t})$ that a certain country takes to adapt to its sustainable public debt level. We therefore estimated the effect of an unexpected shock (one-time only) on the RER, assuming that the RER will not react contemporaneously to changes in the other model variables and that the other variables (EPD/GDP, ρ, g) do not react contemporaneously to shocks in the other variables, except for changes in the RER. Moreover, the path of the EPD/GDP is estimated separately from the shocks to the rest of the variables (i.e., the only shock that is received throughout the period of analysis is to the RER).

The results are presented in figure 1, panels A-E. This figure shows the response of foreign public debt-to-GDP ratio to a one standard deviation shock in the RER. The results show the responses over a horizon of 25 quarters. The figure shows that the

[14] Like in Blanchard and Perotti (2002), the discretionary responses are assumed to take more than one quarter to appear and, therefore, they do not capture the quarterly data from the series used.
[15] See Perotti (2005) for a more in-depth discussion of this subject.

foreign public debt-to-GDP ratio increases and that this effect lasts for approximately 2 to 3 years in the cases of Brazil, Chile, Colombia and Mexico, and 10 years in the case of Peru.

Hence, for the simulations in our model, we will assume that the time in which the country has to return to an acceptable level of public debt (in the sense discussed in the previous section) is three years but we also use a range of between 1 and 10 years.

Figure 1
(around here)

Public Debt and Growth

Finally, we turn to the question of the effect of public debt on growth (equation 11). To find the answer, we estimate the following dynamic regression:

$$(12) \quad g_{it} = \beta_1 + \beta_2 g_{it-1} + \beta_3 \left(\frac{External\ Public\ Debt}{GDP} \right)_{it} + \beta_4 RER_{it} + \beta_5 r_{it} + \lambda_t + \mu_i + \nu_{it}$$

We also use the Arellano and Bond methodology in this estimation since this is a dynamic equation and some of the explanatory variables are endogenous. Table 2 presents the results. The coefficient of public debt is negative and statistically significant, indicating that growth declines as debt increases. The coefficient indicates that one percentage point increase in the public debt-to-GDP ratio reduces the growth rate by 0.14 percentage points in the short term and by about 0.3 percentage points in the long term.

The Sargan test and the second-order residual serial correlation tests confirm the fact that the errors are serially uncorrelated and the validity of the instrumental variables.

Table 2
Estimates using Arellano-Bond model

Dependent Variable: GDP growth rate$_t$

	Equation 1	Equation 2	Equation 3
GDP growth rate $_{t-1}$	0.547 (0.073)***	0.534 (0.088)***	0.557 (0.070)***
External Public Debt/GDP$_t$	-0.143 (0.063)**	-0.164 (0.060)***	-0.172 (0.064)***
RER$_t$	-	0.017 (0.013)	0.0005 (0.026)
r_t	-	-	0.149 (0.241)
Time Effect	YES	YES	YES
Sargan Test (p-value)	1.0000	1.0000	1.0000
Serial Correlation order 1	0.0657	0.0697	0.0497
Serial Correlation order 2	0.2734	0.2617	0.3000
Observations	150	149	149
Groups	5	5	5

Robust standard errors in parenthesis
* significant at 10%; ** significant at 5%; *** significant at 1%

5. Simulations

In this section, we simulate the sustainable primary balance and debt dynamics of a country that faces an initial real depreciation. The primary balance path is represented by equation (6) while the public debt path is represented by equation (9).

Table 3 contains the parameters used in our simulation. From our empirical analysis in section 3, we assume a range of one to ten years for $\bar{t}$, although we assume that for most of the cases is about three years. This means that in three years the country has to adjust to the desired long-term public debt ratio. In the lowest part of the range the country has to adjust within the first year to the desired long-term public debt ratio while in the upper part of the range, it will have ten years to return to that level. From our growth panel regression, we assume that the parameter that relates growth to debt is -0.143 and the parameter that relates interest rate to debt is 0.167.

We also assume that the country starts at a point where $\delta_t = \delta^*$. This is where the desired stock of this country's public debt is equal to its actual stock. For δ^*, we assume a value of 0.35 based on recent literature that considers that the sustainable public debt-to-GDP ratio in LDCs is in the range of 30% to 40%.[16] Note that for countries that have access to concessional debt, the relevant number is the present value of that debt rather than its face value. In our first simulation, we assume that 55% of that debt is denominated in foreign currency or indexed to the exchange rate. In the countries considered in this paper, the average is around that figure, with Chile having the lowest (10%) and Peru the highest (80%). However, in the poorest countries, this fraction approaches 100%, which is why we performed a second set of simulations where 70% of public debt is denominated in foreign currency.

For both scenarios, the real GDP is assumed to grow at 4% per year when $\delta_t = \delta^*$. As δ_t increases, GDP growth declines according to the parameter mentioned above. As shown in Edwards and Vergara (2001 and 2002), the GDP growth rate is critical for the sustainable path of the primary balance. As the primary focus of this paper is debt valuation issues, we do not simulate for different base rates of growth (this is the rate of growth when $\delta = \delta^*$), although it is clear that as g^* increases, the sustainable primary balance declines. Finally, the real interest rate on domestic public debt when $\delta = \delta^*$ is assumed to be 5%. This is consistent with a 2.5% international real interest rate plus a risk premium of 250 basis points.[17]

Seigniorage is assumed to be 0.4% of GDP, which is consistent with a monetary base of 6% of GDP, an inflation rate of 3% per year (hence a nominal GDP growth of 7%) and a unitary elasticity of the demand for money with respect to the GDP.

[16] Edwards and Vergara (op. cit.), Edwards (op. cit.).

[17] Remember that we assume that $E(\hat{RER}) = 0$.

Results

From our assumptions and using (6), we find that with no devaluation, the steady-state primary balance consistent with fiscal sustainability for this theoretical country is a deficit of -0.05% of GDP.

Now we assume a real devaluation of 25% at the end of period zero. As we mentioned earlier, it is assumed that there are no further expected changes in the real exchange rate.[18] Table 4 shows the results of our simulations for different values of $\bar{t}$ and for 10 years after the devaluation occurs, when 55% of public debt is denominated in foreign currency. Panel A shows the primary balance sustainable path. If the country has three years to adjust to the equilibrium debt-to-GDP ratio, it has to have a primary surplus of 1.11%, 0.94% and 0.61% in the first three years. This means a primary balance adjustment of between 1.16% to 0.66% of GDP per year for three years as compared to the non-devaluation situation. This is clearly not a minor adjustment for a country which was supposed to be fiscally sustainable. Panel B shows the path of public debt as a percentage of GDP. For the same $\bar{t}$ = 3, it goes up to 39.8% of GDP just after the devaluation. At the end of the first year, it is down to 38.2% of GDP and it is back to its equilibrium level (35%) at the end of period 3. Interest rates (panel C) go up to 5.82% at the end of year 1 and back to 5.0% in year 4.[19] Growth declines to 2.9% in the first year and returns to 4% after the fourth year.

If the country has to adjust in just one year, debt goes back to its initial level at the end of year 1. But the required adjustment in the primary balance in that year is 1.7% of GDP.

In Table 5 we simulate the case when 70% of public debt is denominated in foreign currency. If the country has three years to return to the equilibrium debt-to-GDP ratio, it has to adjust its primary balance between 1.5% to 0.84% of GDP per year for

[18] This is clearly a simplifying assumption since it can be expected that the fiscal adjustment would produce further changes in the exchange rate. Nonetheless, although the fiscal adjustment obtained in this exercise is large as compared to fiscal expenditure, it is relatively small as compared to the overall aggregate demand of the economy. Hence, it is reasonable to assume that the further effects over the real exchange rate are rather small.

[19] Notice that neither growth nor the interest rate return to their previous levels immediately after $\bar{t}$ years due to the presence of persistence in these variables.

three years as compared to the non-devaluation situation. Public debt goes up to 41.1% of GDP just after the devaluation. At the end of the first year, it is down to 39.1% of GDP and it is back to its equilibrium level (35%) at the end of period 3. Interest rates (panel C) go up to 6.04% at the end of year 1 and back to 5.00% in year 4. Growth declines to 2.56% in the first year and returns to 4% after the fourth year.

In a more extreme scenario, where the fraction of public debt denominated in foreign currency is 70% and the real devaluation is 50%, the average primary balance adjustment, when the adjustment period is three years, is 2.5% of GDP per year as compared to the non-devaluation situation. In this case, interest rates would jump to 7% and GDP growth would decline to 1.1%.

Table 3
Parameter Values Used in the Fiscal Sustainability Analysis

Parameter	Symbol	Assumed Value	Comments and sources
Desired (and initial) external public debt to GDP ratio	δ^*	35%	Common figure used for sustainability analyses based on demand for public sector debt (see Edwards and Vergara, 2002).
Initial foreign currency denominated debt as percentage of total debt	$(e_o F_0/D_0)$	55%-70%	Fraction of public debt that is in foreign currency. From the actual data of LA countries.
Real interest rate when $\delta=\delta^*$	r_0	5.0%	It is assumed to be equal to $r^*+\rho=r^{FC}$
Parameter that relates interest rates in t with interest rate in t-1 (persistence)	α_2	0.241	GMM estimator in autoregressive panel data model.
Parameter that relates changes in interest rates as debt changes	α_3	0.167	GMM estimator in autoregressive panel data model.
Rate of real GDP growth when $\delta=\delta^*$	g_0	4%	Simulation can be made using different rates of growth.
Parameter that relates GDP growth rate in t with GDP growth rate in t-1	β_2	0.547	GMM estimator in autoregressive panel data model.
Parameter that relates changes in growth as debt changes	β_3	-0.143	GMM estimator in autoregressive panel data model.
Time to come back to the desired public debt ratio after the devaluation	$\bar{\tau}$	Between 1 and 10	According to impulse response functions
Seigniorage	S/Y	0.4%	Consistent with a monetary base of 6% of GDP and a nominal GDP growth of 7%.

Table 4

Real devaluation of 25%
Initial foreign currency-denominated debt as a percentage of total debt: 55%

Panel A
Primary balance

Period	$\bar{t}$ = 1	3	5	7	10
0	-0.05	-0.05	-0.05	-0.05	-0.05
1	1.69	1.11	0.99	0.94	0.91
2	0.02	0.94	0.96	0.97	0.98
3	-0.04	0.61	0.76	0.83	0.88
4	-0.05	-0.02	0.55	0.67	0.77
5	-0.05	-0.05	0.35	0.52	0.66
6	-0.05	-0.05	-0.03	0.37	0.55
7	-0.05	-0.05	-0.05	0.23	0.45
8	-0.05	-0.05	-0.05	-0.04	0.35
9	-0.05	-0.05	-0.05	-0.05	0.25
10	-0.05	-0.05	-0.05	-0.05	0.15

Panel B
Public debt (% of GDP)

Period	$\bar{t}$ = 1	3	5	7	10
0	39.81	39.81	39.81	39.81	39.81
1	35.00	38.21	38.85	39.13	39.33
2	35.00	36.60	37.89	38.44	38.85
3	35.00	35.00	36.93	37.75	38.37
4	35.00	35.00	35.96	37.06	37.89
5	35.00	35.00	35.00	36.38	37.41
6	35.00	35.00	35.00	35.69	36.93
7	35.00	35.00	35.00	35.00	36.44
8	35.00	35.00	35.00	35.00	35.96
9	35.00	35.00	35.00	35.00	35.48
10	35.00	35.00	35.00	35.00	35.00

Panel C
Real interest rate

Period	$\bar{t}$ = 1	3	5	7	10
0	5.00	5.00	5.00	5.00	5.00
1	5.34	5.82	5.91	5.95	5.98
2	5.00	5.47	5.71	5.81	5.88
3	5.00	5.12	5.49	5.65	5.78
4	5.00	5.00	5.28	5.50	5.67
5	5.00	5.00	5.07	5.35	5.56
6	5.00	5.00	5.00	5.20	5.46
7	5.00	5.00	5.00	5.05	5.35
8	5.00	5.00	5.00	5.00	5.25
9	5.00	5.00	5.00	5.00	5.14
10	5.00	5.00	5.00	5.00	5.03

Panel D
Rate of real GDP growth

Period	$\bar{t}$ = 1	3	5	7	10
0.00	4.00	4.00	4.00	4.00	4.00
1	3.37	2.87	2.77	2.72	2.69
2	3.94	3.23	2.93	2.81	2.71
3	3.99	3.72	3.23	3.01	2.85
4	4.00	3.98	3.53	3.23	3.00
5	4.00	4.00	3.83	3.45	3.16
6	4.00	4.00	3.98	3.66	3.31
7	4.00	4.00	4.00	3.88	3.46
8	4.00	4.00	4.00	3.99	3.61
9	4.00	4.00	4.00	4.00	3.76
10	4.00	4.00	4.00	4.00	3.92

Table 5

Real devaluation of 25%
Initial foreign currency-denominated debt as a percentage of total debt: 70%

Panel A
Primary balance

	$\bar{t}$				
Period	**1**	**3**	**5**	**7**	**10**
0	-0.05	-0.05	-0.05	-0.05	-0.05
1	2.17	1.45	1.31	1.25	1.20
2	0.04	1.23	1.26	1.28	1.30
3	-0.04	0.79	0.99	1.09	1.16
4	-0.05	-0.01	0.72	0.88	1.01
5	-0.05	-0.05	0.46	0.68	0.87
6	-0.05	-0.05	-0.03	0.49	0.73
7	-0.05	-0.05	-0.05	0.31	0.59
8	-0.05	-0.05	-0.05	-0.03	0.46
9	-0.05	-0.05	-0.05	-0.05	0.33
10	-0.05	-0.05	-0.05	-0.05	0.20

Panel B
Public debt (% of GDP)

	$\bar{t}$				
Period	**1**	**3**	**5**	**7**	**10**
0	41.1	41.1	41.1	41.1	41.1
1	35.0	39.1	39.9	40.3	40.5
2	35.0	37.0	38.7	39.4	39.9
3	35.0	35.0	37.5	38.5	39.3
4	35.0	35.0	36.2	37.6	38.7
5	35.0	35.0	35.0	36.8	38.1
6	35.0	35.0	35.0	35.9	37.5
7	35.0	35.0	35.0	35.0	36.8
8	35.0	35.0	35.0	35.0	36.2
9	35.0	35.0	35.0	35.0	35.6
10	35.0	35.0	35.0	35.0	35.0

Panel C
Real interest rate

	$\bar{t}$				
Period	**1**	**3**	**5**	**7**	**10**
0	5	5	5	5	5
1	5.44	6.04	6.16	6.21	6.25
2	5.00	5.60	5.90	6.03	6.12
3	5.00	5.15	5.63	5.83	5.99
4	5.00	5.00	5.36	5.64	5.85
5	5.00	5.00	5.09	5.45	5.72
6	5.00	5.00	5.00	5.26	5.58
7	5.00	5.00	5.00	5.06	5.45
8	5.00	5.00	5.00	5.00	5.31
9	5.00	5.00	5.00	5.00	5.18
10	5.00	5.00	5.00	5.00	5.04

Panel D
Rate of real GDP growth

	$\bar{t}$				
Period	**1**	**3**	**5**	**7**	**10**
0	4.00	4.00	4.00	4.00	4.00
1	3.20	2.56	2.43	2.38	2.34
2	3.93	3.02	2.64	2.48	2.36
3	3.99	3.65	3.01	2.74	2.54
4	4.00	3.97	3.40	3.02	2.73
5	4.00	4.00	3.79	3.30	2.93
6	4.00	4.00	3.98	3.57	3.12
7	4.00	4.00	4.00	3.85	3.31
8	4.00	4.00	4.00	3.99	3.51
9	4.00	4.00	4.00	4.00	3.70
10	4.00	4.00	4.00	4.00	3.89

6. Conclusions

Ignoring valuation issues can lead to misleading conclusions regarding fiscal sustainability. We have shown that starting from a point where the country is in a sustainable fiscal position, a devaluation can dramatically change the path of primary balances consistent with current fiscal sustainability. Assuming that the country has three years to return to the equilibrium public debt-to-GDP ratio, the required primary balance adjustment after the devaluation is about 1% of GDP for each of those three years. The longer the adjustment period is, the smaller the adjustment. The larger the share of foreign currency-denominated debt, the greater the required fiscal adjustment while the greater the initial devaluation, the greater the fiscal adjustment.

This conclusion is important for poor countries that have a large share of public debt in foreign currency and frequently face terms of trade or other shocks that result in considerable depreciations of the domestic currency. With fiscal positions that usually are very tight, a required adjustment of the magnitudes found in this paper can be very stressful for these countries.

In this paper, we have assumed that the only factor affecting fiscal sustainability when there is a depreciation of the domestic currency is the change in the valuation of the public debt that is denominated in foreign currency. However, some developing countries have state-owned companies that produce commodities that are exported.[20] If this is the case, the devaluation also produces a positive revenue effect which works in the opposite direction of the effect studied in this paper.

[20] Even if the companies are not state-owned, there is an effect through tax revenues obtained from private companies producing and exporting commodities.

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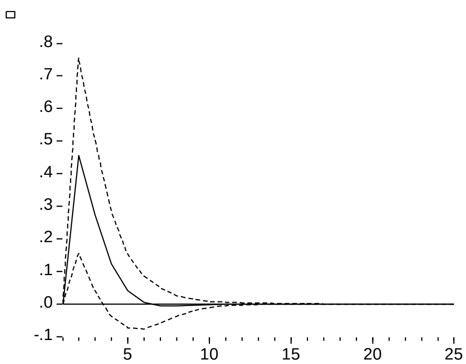
Figure 1

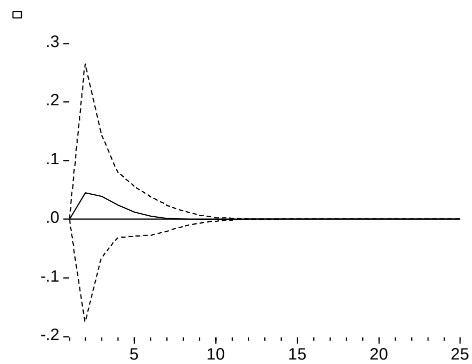
Impulse Response Functions

Response of External Public Debt-to-GDP ratio to One S.D. RER Innovation

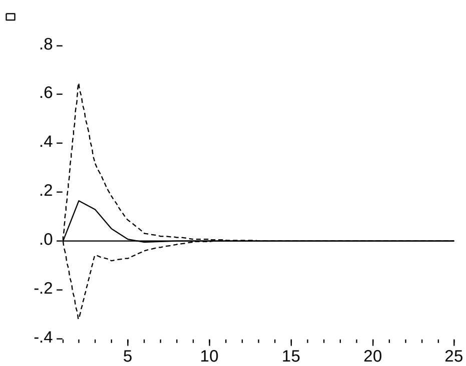
Panel A: Brazil



Panel B: Chile



Panel C: Colombia



Panel D: Mexico

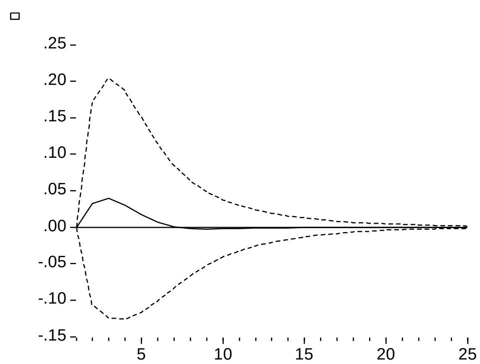


Figure 1 (Cont.)
Impulse Response Functions

Response of External Public Debt-to-GDP ratio to One S.D. RER Innovation

Panel E: Peru