ISSN 1518-3548

BANCO CENTRAL DO BRASIL

Overcoming the Original Sin: gains from local currency external debt

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September 2018

Working Papers

484

ISSN 1518-3548
CGC 00.038.166/0001-05

Working Paper Series	Brasília	no. 484	September	2018	p. 1-41

Working Paper Series

Edited by the Research Department (Depep) – E-mail: workingpaper@bcb.gov.br

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Non-technical Summary

Until the early 2000s, emerging countries did not borrow from foreigners using instruments denominated in their own currencies. Eichengreen and Hausmann (1999) named this fact the "original sin". In the last decade, however, emerging markets seem to have overcome, at least partially, this shortcoming. The overcoming occurs mostly through the increasing participation of international lenders in local government debt markets.

When investing in debt denominated in emerging countries' currencies, foreign investors care about the exchange rate depreciation, because they are interested in returns measured in their own currencies (usually US dollars or Euros). Since the inflation rate is a determinant of the exchange rate depreciation, low inflation is an important attraction factor for foreign investors to local currency bonds. Nevertheless, currency depreciation is not the only concern for an investor in these markets. Recent empirical studies reveal that even government debt denominated in local currency is not free from explicit defaults.

Inspired by the combination of increased foreign participation in local debt markets, improved monetary policy frameworks, and default risk, I investigate the consequences of issuing external debt denominated in domestic currency, instead of foreign, in a simulated computational economy that replicates some features of the Brazilian economy. In this artificial environment, the policymaker can default on its external debt regardless of the currency of denomination. In an economy issuing local currency debt, the use of inflation can avoid an explicit and costly default by increasing the exchange rate (depreciating the domestic currency) and, consequently, reducing the value of the debt when measured in foreign currency. This action can be beneficial if used during times of subpar GDP growth. However, if used indiscriminately, such an option leads to excessive inflation.

Assuming that the policymaker cannot commit to its future actions, I find that an economy issuing local currency debt defaults less often, sustains lower debt levels, and has higher inflation. The net effect is a welfare loss if debt is denominated in local currency. However, if the policymaker can credibly commit not to use inflation to erode the debt, welfare increases. In this case, the real exchange rate (i.e., the nominal rate adjusted for the effects of domestic and external inflation) serves as a buffer to accommodate negative GDP surprises and to prevent defaults. In either case, the welfare change is of limited size.

Sumário Não Técnico

Até o início dos anos 2000, países emergentes não obtinham empréstimos de estrangeiros usando suas próprias moedas. Eichengreen e Hausmann (1999) chamaram esse fato de "pecado original". Na última década, no entanto, os mercados emergentes parecem ter superado, ao menos parcialmente, essa dificuldade. A superação ocorre principalmente através da participação crescente de credores internacionais nos mercados locais dívida pública.

Ao investir em dívidas denominadas em moedas de países emergentes, os investidores estrangeiros preocupam-se com a depreciação da taxa de câmbio, porque estão interessados em retornos medidos em suas próprias moedas (geralmente dólares americanos ou euros). Como a taxa de inflação é um determinante da depreciação da taxa de câmbio, inflação baixa é um importante fator de atração de investidores estrangeiros para títulos em moeda local. No entanto, a depreciação da moeda não é a única preocupação para um investidor nesses mercados. Estudos empíricos recentes revelam que mesmo a dívida do governo denominada em moeda local não está livre de calotes explícitos.

Diante dessa combinação de maior participação de estrangeiros em dívidas locais, melhores arcabouços de política monetária e risco de inadimplência, investigam-se as consequências de se emitir dívida em moeda nacional, em vez de estrangeira, em uma economia computacional simulada que replica algumas características da economia brasileira. Nesse ambiente artificial, o formulador de políticas pode inadimplir sua dívida externa, independentemente da moeda de denominação. Quando esta economia emite dívida em moeda local, o uso da inflação pode evitar um default explícito e oneroso ao aumentar a taxa de câmbio (depreciando a moeda doméstica) e, consequentemente, diminuindo o valor da dívida quando medida em moeda estrangeira. Essa conduta pode ser benéfica se usada durante períodos de baixo crescimento do PIB. Todavia, se usada indiscriminadamente, essa opção leva a inflação excessiva.

Supondo que o formulador de políticas não possa se comprometer com suas ações futuras, os resultados mostram que uma economia que emite dívida em moeda local inadimple com menos frequência, sustenta níveis mais baixos de dívida e apresenta inflação mais alta. O efeito líquido é uma perda de bem-estar se a dívida for denominada em moeda local. No entanto, se o formulador de políticas puder comprometer-se crivelmente a não usar a inflação para corroer o montante da dívida, há ganhos de bem-estar. Nesse caso, a taxa de câmbio real (isto é, a taxa nominal ajustada pelos efeitos das inflações doméstica e externa) serve como um colchão para acomodar surpresas negativas do PIB e evitar inadimplementos. Em ambos os casos a mudança de bem-estar tem magnitude limitada.

Overcoming the Original Sin: gains from local currency external debt [*]

Ricardo Sabbadini[**]

Abstract

Is it better for emerging countries to issue external debt denominated in local (LC) or foreign currency (FC)? An economy issuing LC debt can avoid an explicit and costly default by inflating away its debt. However, in the hands of a discretionary policymaker, such tool might lead to excessive inflation and negative consequences for welfare. To investigate this question, I develop a quantitative model of sovereign default extended to incorporate real exchange rates and inflation. I find that an economy issuing LC debt defaults less often, sustains slightly lower debt levels, and presents positive average inflation. The net effect is a modest welfare loss when compared to issuing debt in FC. However, if monetary policy is credible, the welfare change is positive, but also of limited size. In this case, the real exchange rate serves as a buffer to accommodate negative output shocks and to prevent defaults.

Keywords: external debt, sovereign default, debt denomination, exchange rate, inflation, discretionary policy
JEL Classification: E43, E61, F31, F34, F41

[*] I thank Fabio Kanczuk, Bernardo Guimarães, Bruno Giovannetti, Márcio Nakane, Carlos Eduardo Soares Gonçalves, Mauro Rodrigues, Laura Alfaro, Gian Soave, Paulo Carvalho Lins, Eurilton Araujo, André Minella, Carlos Viana de Carvalho, Cristiano Costa Carvalho, Pedro Henrique Castro, Felipe Estácio de Lima Correia, Tamon Asonuma, Javier García-Cicco, Juan Passadore, Juan Carlos Hatchondo and seminar participants at Central Bank of Brazil, Workshop on International Macro of RIDGE/Central Bank of Uruguay, 39º Meeting of the Brazilian Econometric Society, and University of Sao Paulo (GEP students' seminar) for valuable comments and suggestions.
I gratefully acknowledge the Weatherhead Center for International Affairs, Harvard University, for its hospitality during the spring semester of 2018.
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1. Introduction

Eichengreen and Hausmann (1999) named the inability of emerging markets to borrow from foreigners using instruments denominated in their own currencies the "original sin". In the last decade, however, emerging markets seem to have overcome, at least partially, this shortcoming. Lane and Shambaugh, (2010) and Bénétrix, Lane, and Shambaugh, (2015) show that emerging markets abandoned negative net external positions in foreign currency (FC) when debt, equity and foreign direct investments are considered. The change of the currency denomination of liabilities from foreign to local also happened when restricting the scope to debt markets. Such outcome occurred mostly through an increasing participation of non-resident lenders in local government debt markets (Burger, Warnock and Warnock, 2010, Arslanalp and Tsuda, 2014, Du and Schreger 2017, Alfaro and Kanczuk, 2017, and Maggiori, Neiman and Schreger, 2018)[1].

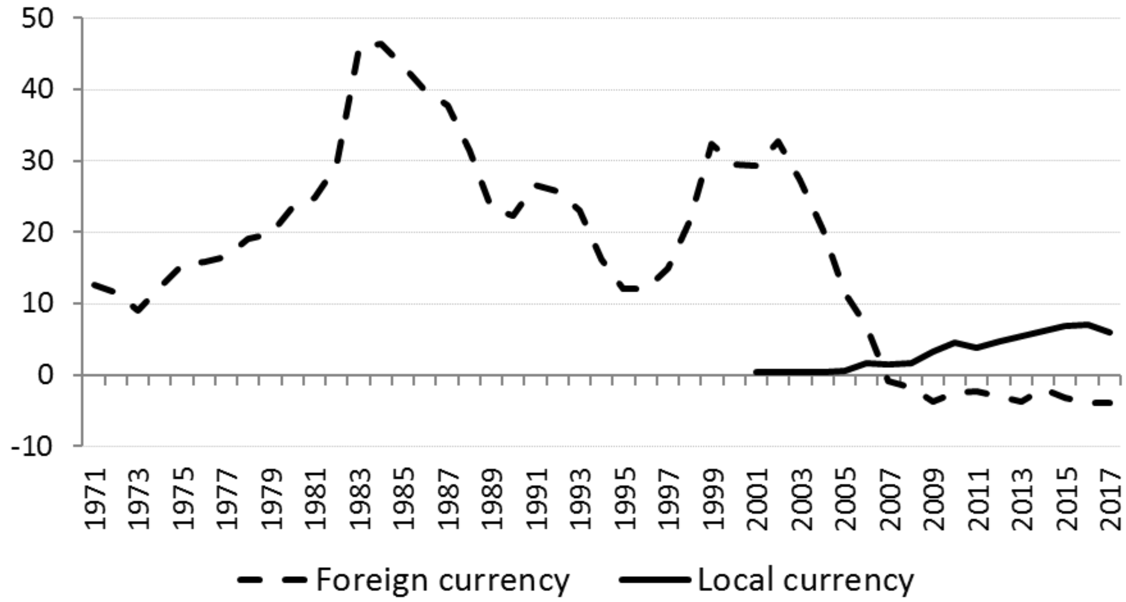
Contemporaneously to the shift in currency denomination of external debt, several emerging countries adhered to inflation targeting regimes (Hammond, 2012) and reduced inflation and its volatility (Vega and Winkelried, 2005, Gonçalves and Salles, 2008, Lin and Ye, 2009, Mendonça and Souza, 2012). Burger, Warnock, and Warnock (2010) show the importance of this development to attract foreign investors to local currency bonds. Nevertheless, inflation is not the only concern for an investor in local currency (LC) bonds in emerging markets. The empirical literature – using both recent and historical data – reveals that even sovereign debt denominated in local currency is not free from de jure defaults (Kohlscheen 2010, Rogoff and Reinhart 2011, Du and Schreger 2016, and Jeanneret and Souissi, 2016).

Inspired by the combination of increased foreign participation in local debt markets, improved monetary policy frameworks, and default risk, I investigate the consequences of changing the denomination of external debt from FC to LC using a small open economy model with endogenous default, real exchange rate and inflation. In such a framework, a discretionary sovereign chooses consumption and borrowing from foreign lenders, whether or not to default, and the inflation rate. Assuming that both default and inflation have negative consequences for the economy, I compare the two possibilities of

[1] In a sample of 22 emerging countries, Arslanalp and Tsuda (2014) show that the median share of foreign ownership of government debt denominated in local currency increased from 2.7% in the last quarter of 2004 to 17.7% in the second quarter of 2016.

debt denomination: FC and LC. In the former case, since inflation cannot erode debt, there is no benefit in increasing the price level. However, if debt is nominal, inflation is a tool available to smooth consumption and to avoid an explicit and costly default. I focus on the contingency in the repayment value of LC debt provided by variations in the exchange rate. This is achieved if the domestic currency depreciates and the value of debt measured in FC declines during bad times (subpar output). The loosening of the resource constraint of the domestic economy allows a less severe contraction in consumption than in the case of FC debt and turns the option to default on debt less attractive.

Figure 1: Brazil net external debt by currency of denomination (% GDP)



Note: The figure plots net external debt positions by currency denomination in annual frequency. Data start in 1971 and 2001 for foreign and local currencies, respectively. Source: Author's computation based on data from the Central Bank of Brazil. More information about data construction in Appendix A.

I calibrate the model with data from Brazil, an emerging market whose external debt denomination is shifting from FC to LC (Figure 1). It is also a country with a long history of defaults, and one of the first non-advanced economies to adopt an inflation target regime. Besides, Brazil is a representative case of the situation of other emerging countries. Values for Brazil and the median are similar in Table 1, which brings external debt information for 12 emerging countries. Considering net positions, data in column 3 reveal that most countries are creditors in foreign currency, in line with the results from

Bénétrix, Lane and Shambaugh (2015) for a broader concept of liabilities. Evidence also shows that countries borrow significant amounts in local currency (column 4).

The policy functions obtained indicate that an economy with LC debt is more likely to default, inflate, and increase the real exchange rate during periods of low output and when the current debt stock is higher. In addition, the sovereign issues more debt during good times, when its cost is lower due to the reduced probability of default. These results remain in an economy with FC debt, except for inflation, that is always zero.

With simulated data, I find that the model with FC debt replicates features of the Brazilian economy (shared by emerging markets in general) during the period of external debt denominated in US dollars (1971-2006). It mirrors the average debt level and the default frequency, and exhibits counter-cyclical behavior for default risk premium, trade balance, and real exchange rate.

Gains and losses appear when the currency denomination changes from FC to LC. The benefits are fewer defaults and less volatility in trade balance, real exchange rate, and default risk premium. Inflation and real exchange rate depreciation – achieved through a reduction in the consumption of traded goods – contribute to a relief of the debt burden in bad times. With the loosening of the resource constrain in such periods, the default frequency declines from 2.4% in the FC case to 1.4%. In the economy with FC debt, the contraction in the consumption of traded goods also increases the real exchange rate, but does not affect the debt burden, due to the currency of denomination of debt.

The disadvantages of LC debt are two: higher inflation and lower debt sustainability. The discretionary sovereign with the ability to use inflation to erode debt has an inflationary bias and creates excessive inflation, negatively affecting domestic welfare. Beyond that, the mean debt-to-GDP ratio falls 0.3pp (equivalent to 3.8%), because interest rate spreads increase on average. Despite a lower default premium, foreign lenders require a compensation for the possibility of expropriation via nominal exchange rate depreciation. Overall, I find a modest negative welfare change from switching from FC to LC debt issuance. The measured effect is a 0.05% fall in the certainty equivalent consumption.

Table 1 – Net external debt by local and foreign currency, 2015.

Country	Gross External Debt		Net Assets in Foreign Currency	Net Debt in Local Currency
	% GDP	% in Local Currency	% GDP	% GDP
	1	2	3	4
India	23.1	28.7	2.4	6.6
Brazil	**25.9**	**22.9**	**5.0**	**5.9**
Mexico	36.5	29.5	10.1	10.8
Russia	28.5	16.4	35.4	4.7
Poland	52.6	35.4	-4.8	18.6
Argentina	22.5	3.9	15.6	0.9
Thailand	29.0	24.8	40.2	7.2
Ukraine	121.7	0.8	6.2	1.0
Chile	43.0	3.7	0.0	1.6
South Africa	32.0	42.6	10.4	13.6
Hungary	74.0	23.0	-7.2	17.0
Romania	41.8	11.2	-5.6	4.7
Median	**34.3**	**22.9**	**5.6**	**6.3**

Note: The table reports gross external debt (public and private) as a share of GDP (column 1), the share of gross external debt denominated in local currency (column 2), the net position of debt instruments in foreign currency (column 3, where positive numbers mean creditor positions), and in local currency (column 4, where positive numbers mean debtor positions). Source: Author's computation based on data from the Quarterly External Debt Statistics Database (IMF/WB), and the Balance of Payments and International Investment Position Statistics (IMF). More information about data construction in Appendix A.

From a descriptive perspective, the model with LC also performs well. As observed for Brazil from 2007 to 2017, the model exhibits counter-cyclical risk premium, trade balance, and real exchange rate, while inflation is pro-cyclical. This last feature, similar to a Phillips curve, occurs because during periods of high output the sovereign accumulates more debt and is more tempted to use inflation. The model also generates a sensible amount of inflation, 2.9%, in comparison to 4.3% in the data.

All the previous results are qualitatively robust to: i) the inclusion of risk-averse lenders, or ii) the use of a lower utility cost of inflation. In the latter robustness exercise, the lower utility cost of inflation can be interpreted as a decrease in the credibility of monetary policy (Onder and Sunel, 2016, Ottonello and Perez, 2016, Du, Pflueger and Schreger, 2017). If this parameter is set so that model's average inflation matches its observed counterpart, the main results remain the same. The average inflation increases from 2.9% to 4.2%, the mean debt-to-GDP ratio falls another 0.2pp, and the welfare loss from changing from FC to LC is 0.10%, instead of 0.05%, in terms of equivalent consumption.

However, if the monetary policy is fully credible and can commit to zero inflation (infinitely high inflation costs), there is a small welfare gain from issuing LC debt (0.07%). In this case, only real exchange rate fluctuations relieve the debt burden during bad times. Therefore, the default frequency falls less, from 2.4% to 1.8%. Nevertheless, since there is no inflation, debt sustainability increases in comparison to the FC case. The relation between monetary policy credibility and the welfare changes from LC debt issuance help us to understand the phenomenon of "original sin" in a different way. If the monetary policy credibility is very low, the government frequently creates inflation and does not borrow a relevant amount. This scenario might lead to meaningful welfare losses if the sovereign issues LC debt. Therefore, when the monetary policy regimes of emerging countries completely lack credibility, the optimal choice is to issue debt in FC. This prediction is in line with evidence of high inflation and low participation of foreigners in local debt markets in emerging countries before the adoption and the adherence to reliable monetary policy regimes. Thus, such absence of inflation credibility in emerging markets is an alternative explanation for the "original sin", opposed to hypothesis of an incompleteness in international financial markets presented by Eichengreen and Hausmann (1999).

This paper contributes to the literature on quantitative models of external debt and default in economies with incomplete markets based on the works of Eaton and Gersovitz (1981), Grossman and Van Huyck (1988), Alfaro and Kanczuk (2005), Aguiar and Gopinath (2006) , and Arellano (2008)[2]. The model presented here connects to two recent strands of this literature.

The first of them uses models with two sectors (traded and non-traded goods) to study real exchange rate determination in settings with credible monetary policy. In such scenarios, the sovereign does not inflate the debt away. Papers in this literature include Gumus (2013), Asonuma (2016), Alfaro and Kanczuk (2017), and Na et al (2018). The first – and more closely related to my work - finds that with LC debt the economy sustains higher quantities of debt and defaults less frequently. The ensuing welfare increase, nonetheless, has a limited magnitude. The model of Asonuma (2016), for an economy

[2] Recent surveys of this approach are Stahler (2013), Aguiar and Amador (2014), and Aguiar et al. (2016).

with debt denominated mostly in FC, replicates the observed depreciation of the real exchange rate around defaults episodes. Alfaro and Kanczuk (2017) extend the model to study the simultaneous accumulation of LC debt and international reserves. Na et al (2018) investigate the consequences of different exchange rate regimes when debt is denominated in FC, non-traded goods are produced using labor, and nominal wage is downward rigid. As Asonuma (2016), they find that sovereign defaults happen concomitantly to exchange rate devaluation. While the default releases resources for consumption, the exchange-rate devaluation reduces the real value of wages, thereby decreasing involuntary unemployment.

The second related literature focuses on nominal debt when monetary policy is discretionary and explicit default is possible. The papers mentioned here, however, use models with a single traded of good, neglecting, therefore, real exchange rate movements. Nuño and Thomas (2016) and Onder and Sunel (2016), inspired by the recent experience of countries in the periphery of the Euro area, find that welfare is higher when debt is issued in FC and there are no incentives to create inflation.

This framework has been extended in several directions and used to investigate various topics. Among others, examples are i) self-fulfilling debt crises in small economies and in monetary unions (Aguiar et al. 2013, 2015, and Araujo et al. 2013); ii) the origin of the default risk on LC sovereign debt coming from FC corporate borrowing and the consequent currency mismatch (Du and Schreger, 2017); iii) how the exogenous cyclicality of the inflation rate influences debt sustainability in a closed economy (Hur, Kondo and Perri, 2017); iv) the complementary role of seigniorage in economies with debt and money (Rottger, 2016, and Sunder-Plassmann, 2017, with cash-in-advance constraints, and Fried, 2017, with search frictions).

My modelling structure is close to that of Ottonello and Perez (2016), but I include explicit default as a policy option. Their paper is part of a literature studying the optimal currency composition of sovereign debt, as are Du, Pflueger and Schreger (2017), and Engel and Park (2018). They find that economies with more credible monetary policies are less tempted to use inflation excessively and issue more nominal debt. Their results suggest that countries should issue at least some share of their debt in local currency, opposing the earlier findings of Alfaro and Kanczuk (2010).

2. Model

I model a small open economy that receives a stochastic endowment of traded goods and a fixed amount of non-traded goods every period. The central planner borrows from risk neutral foreign lenders using only debt (a non-contingent instrument). I compare the cases of debt denominated in foreign and local currencies. Since the sovereign cannot commit to repay, every period it chooses whether or not to default on the stock of debt. In case of default, the country is excluded from international markets by a random number of periods. If the government decides to continue participating in markets, it is able to borrow today due to the next period, when a decision between default and repayment is made again. Every period the sovereign also chooses its preferred inflation rate.

Household preferences, in equations (1) and (2), follow the same specification of Ottonello and Perez (2016), who study endogenous exchange rate and local currency debt[3].

$$U = \boldsymbol{E}_{t=0} \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{\gamma}{2} \pi_t^2 \right) \tag{1}$$

$$C_t(c^T, c^N) = (c_t^T)^{\alpha} (c_t^N)^{1-\alpha} \tag{2}$$

In the expressions above, $\boldsymbol{E}$ is the expectation operator, and C_t is the aggregate household consumption, comprised of c_t^T and c_t^N, traded and non-traded goods, respectively. The household utility is negatively influenced by the inflation rate, π_t. The four parameters express the subjective discount rate, β, the constant coefficient of relative risk aversion, σ, the share of tradable goods in the utility function, α, and the inflation cost, γ.

The endowment of the traded good, y_t^T, follows the autoregressive process described in equation (3), with ε_t representing a white noise with standard normal distribution. In order to reduce the number of state variables in the problem, I normalize

[3] Ottonello and Perez (2016) show that models with cash-in-advance constraints or with money in the utility function are a possible foundation of this functional form. Nuno and Thomas (2016) and Du, Pflueger and Schreger, (2017) also assume quadratic inflation costs in the utility function in models of sovereign debt. The former show that such functional form can be justified on the grounds of costly price adjustment by firms.

the fixed amount of non-traded goods to one, as Alfaro and Kanczuk (2017) and Ottonello and Perez (2016) do. Thus, in equilibrium we have that $c_t^N = y_t^N = 1$.

$$\ln(y_t^T) = \rho \ln(y_{t-1}^T) + \eta \varepsilon_t \quad (3)$$

The prices of traded and non-traded good are denoted by p_t^T and p_t^N, respectively. I assume that the price of the traded good in the international economy is stable and normalize it to one, $p^* = 1$. Using the law of one price, I find that $p_t^T = p^* e_t = e_t$, in which e_t is the nominal exchange rate. An increase in the nominal exchange rate represents a depreciation of the domestic currency. The aggregate price level is the solution to the minimization problem in equation (4) subject to $C_t = 1$.

$$P_t \equiv \min_{(c_t^T, c_t^N)} e_t c_t^T + p_t^N c_t^N \quad (4)$$

Given the functional forms, equation (5) presents the solution relating the aggregate price and the nominal exchange rate. Equation (6) defines the inflation rate.

$$P_t = e_t \frac{1}{\alpha} \left(\frac{c_t^T}{c_t^N} \right)^{1-\alpha} \quad (5)$$

$$\pi_t = \frac{P_t}{P_{t-1}} \quad (6)$$

If debt is denominated in FC and the sovereign opts for honoring its obligation, keeping its access to the international financial markets, equation (7) expresses the resource constraint of the economy. In this expression, d_t^* and q_t^* denote the amount of FC debt and its price, respectively. In an economy issuing LC debt, the resource constraint is equation (8), and the quantity of debt and its price are represented by d_t and q_t in the order given.

$$e_t c_t^T + p_t^N c_t^N = e_t y_t^T + p_t^N y_t^N + e_t q_t^* d_{t+1}^* - e_t d_t^* \quad (7)$$

$$e_t c_t^T + p_t^N c_t^N = e_t y_t^T + p_t^N y_t^N + q_t d_{t+1} - d_t \quad (8)$$

Using the equilibrium condition $c_t^N = y_t^N$, equation (9) shows the resource constraint, regardless of the currency of debt denomination, if the sovereign defaults. In this situation, the sovereign does not repay its debt, neither borrows more. As usual in this literature, the economy faces a direct output cost when it defaults. This assumption is required to sustain positive debt levels, because exclusion from markets is not a punishment harsh enough to do so.

I model this loss using the same specification as Arellano (2008), equation (10). It is frequently used in this literature, and consistent with the empirical observation[4]. This expression means that there are no direct costs of default for output levels up to a certain threshold (ψ). Above such point, the direct costs become positive and increase with output[5]. This functional form captures the idea that output cannot be high even under a good productivity shock. One interpretation, proposed by Arellano (2008), is that defaults are associated with disruptions in the domestic financial market and that credit is an essential input for production. Following Alfaro and Kanczuk (2017), I restrict the cost to the tradable sector of the economy, because it is the only one with a stochastic component.

$$c_t^T = y_t^{T,a} \tag{9}$$

$$y_t^{T,a} = \begin{cases} y_t^T \text{ , } if \ y_t^T \leq \psi \\ \psi . \ if \ y_t^T > \psi \end{cases} \tag{10}$$

Foreign lenders, who have access to a risk-free asset with return r^*, price the debt, that reflects the sovereign's actions. They price the bond's payoff using the reduced form stochastic discount factor in equation (11). In this specification, already used in this type of model by Arellano and Ramanarayanan (2012) and Bianchi, Hatchondo and Martinez (2018), the parameter κ governs the risk premium and its correlation with the stochastic process for y_t^T. While $\kappa = 0$ leads to risk neutrality pricing, positive values imply that lenders value more returns in states with negative income shocks in the small open economy. These are exactly the times when default is more likely to happen.

[4] See Mendoza and Yue (2012) for a general equilibrium model of sovereign defaults and business cycles that generates non-linear output costs of default. The asymmetry happens due to working capital financing constraints for imported inputs that lack perfect domestic substitutes.
[5] According to Aguiar et al (2016), an asymmetric output cost of default is essential to replicate sensible values of average debt and default frequencies in this type of model.

$$m_{t+1} = exp(-r^* - \kappa\eta\varepsilon_{t+1} - 0.5\kappa^2\eta^2) \tag{11}$$

Equation (12) shows that the price of FC debt depends on the default decision that the sovereign makes in the next period ($f_t = 1$ means the government defaults and $f_t = 0$ means it repays). The default decision in period $t+1$, in its turn, is a function of the state variables y_{t+1}^T and d_{t+1}^*. Hence, the price of debt in period t hinges on the current endowment of traded goods and the amount borrowed in period t for repayment in $t+1$. The former variable is relevant because it brings information about its next realization due to the autocorrelation in the stochastic process for y_t^T. This justifies the use of the conditional expectations operator, $\boldsymbol{E_y}$, in the pricing equations. The price of LC debt, equation (13), also depends on the depreciation of the nominal exchange rate, because foreign investors are interested in the return measured in FC. Since the current and future nominal exchange rates appear in the right hand side of equation (13), the price of LC debt is a function of y^T, d_t, and d_{t+1}.

$$q_t^*(y^T, d_{t+1}^*) = \boldsymbol{E_y}[m_{t+1}(1 - f_{t+1})] \tag{12}$$

$$q_t(y^T, d_t, d_{t+1}) = \boldsymbol{E_y}\left[m_{t+1}(1 - f_{t+1})\frac{e_t}{e_{t+1}}\right] \tag{13}$$

Using, $c_t^N = y_t^N$, note that the resource constraint for the FC economy (7) can be reduced to (14). It makes clear that i) the problem can be interpreted as the single good canonical model rescaled, and ii) inflation cannot be used to decrease the real value of debt via nominal exchange rate depreciation. Since there are inflation costs, but no benefits, the sovereign chooses $\pi_t = 0$. In the LC case, inflation is not necessarily zero. Besides, equation (15), derived from (5) and (8) and using $c_t^N = y_t^N$, shows that P_{t-1} is a state variable, because $P_t = \pi_t P_{t-1}$.

$$c_t^T = y_t^T + q_t^* d_{t+1}^* - d_t^* \tag{14}$$

$$c_t^T = y_t^T + \frac{1}{P_t}\frac{1}{\alpha}\left(\frac{c_t^T}{c_t^N}\right)^{1-\alpha}(q_t d_{t+1} - d_t) \tag{15}$$

In order to reduce the dimension of the problem, and write it in a recursive manner, I present a de-trended version of this economy. First, I define ϵ_t, the real exchange rate, $\hat{d}_t$, a measure of debt scaled by the price level of the previous period, and $\tilde{q}_t$, an auxiliary price variable associated with LC debt, in equations (16) to (18)[6]. Then, equation (19) expresses the de-trended resource constraint for the LC economy, already plugged with equation (5), the equilibrium condition for the exchange rate.

$$\epsilon_t = \frac{e_t}{P_t} = \frac{1}{\alpha}\left(\frac{c_t^T}{c_t^N}\right)^{1-\alpha} \tag{16}$$

$$\hat{d}_t = \frac{d_t}{P_{t-1}} \tag{17}$$

$$\tilde{q}_t(y^T, d_{t+1}) = \frac{q_t}{\epsilon_t} \tag{18}$$

$$c_t^T = y_t^T + \tilde{q}_t \hat{d}_{t+1} - \frac{\hat{d}_t}{\epsilon_t \pi_t} \tag{19}$$

Equations (20), (21) and (22) present the problem in recursive form. As usual in the literature, variables with apostrophe represent values at $t + 1$. For the value functions and restrictions defined below, we obtain policy functions for default (f), consumption of traded goods (c^T), inflation (π), and next period debt (d^* or d depending on the currency of denomination). For the sovereign, the value of repaying is expressed by (20) subject to the resource constraint: equation (14) in case of FC debt or equation (19) in case of LC debt. The value of defaulting, (21), depends only on the current endowment. The parameter θ measures the exogenous probability of regaining access to the international markets with zero debt after default. Equation (22) depicts the discretionary government deciding at every period whether to repay and or to default.

$$V^R(y^T, \hat{d}) = \max_{\hat{d}', c^T, \pi} \{u(C(c^T, y^N), \pi) + \beta E_y[V(y^{T\prime}, \hat{d}')] \,, \tag{20}$$

subject to (14) for FC debt or (19) for LC debt.

[6] See Appendix B for a more detailed expression connecting q_t and $\tilde{q}_t$, and to see why the latter is not a function of the current debt level.

$$V^D(y^T) = u(C(y^{T,a}, y^N),0) + \beta E_y[\theta V^R(y', 0) + (1-\theta)V^D(y^{T\prime}) \quad (21)$$

$$V\left(y^T, \hat{d}\right) = \max_{f \in \{0,1\}} \{ (1-f)V^R\left(y^T, \hat{d}\right) + fV^D(y^T)\} \quad (22)$$

The model is a stochastic dynamic game played by a discretionary sovereign, who cannot commit to a planned policy path, against a continuum of small identical foreign lenders. Given the lack of commitment I focus on Markov Perfect Equilibrium.

Definition. Let $s = \{y^T, d^*\}$ for FC debt and $s = \{y^T, d\}$ for LC debt. A Markov perfect equilibrium is defined by:

i) A set of value functions $V(s), V^R(s), V^D(s)$ defined above;

ii) Policy functions for default, $f(s)$, consumption of traded goods, $c^T(s)$, inflation, $\pi(s)$, and borrowing, $d^{*\prime}(s)$ for FC debt and $d'(s)$ for LC debt;

iii) A bond price function: q^* for FC debt and $\tilde{q}$ for LC debt,

such that

I) Given a bond price function, the policy functions solve the Bellman equations (20) - (22);

II) Given the policy functions, the bond price function satisfies equation (12) for FC debt or (18) for LC debt[7].

3. Calibration

I solve the model for two different specifications, one under risk-neutrality ($\kappa = 0$) and other with risk-averse lenders ($\kappa > 0$). Seven out of the ten model parameters have the same value for both specifications (Table 2). The choices for the risk-free international interest rate, $r^* = 0.04$ for annual frequency, and for the domestic risk

[7] Equation (B2) in the appendix shows the exact association between $\tilde{q}$ and the policy functions.

aversion coefficient, $\sigma = 2$, are standard in the literature. In line with estimates by Gelos, Sahay and Sandleris (2011), the probability of redemption after default, θ, is set at 0.5. This leads to two years of exclusion from markets on average. As Ottonello and Perez (2016), for simplicity I set equal shares for tradables and non-tradables in the consumption aggregator[8], $\alpha = 0.5$. For the cost of inflation, I use $\gamma = 1.30$. According to Ottonello and Perez (2016), such value generates welfare costs of inflation in line with estimates by Lucas (2000) and Burstein and Hellwig (2008). This differs from the approach of Nuno and Thomas (2016) and Du, Pflueger and Schreger (2017), who set the inflation cost parameter to target a desired average inflation.

Table 2 – Parameter values

Parameter	Description	Value	
		Benchmark	Risk averse lenders
σ	Domestic risk Aversion	2,00	2,00
r*	Risk free rate	0,04	0,04
γ	Inflation cost	1,30	1,30
θ	Probability of re-entry after default	0,50	0,50
α	Share of traded output	0,50	0,50
ρ	GDP persistence	0,70	0,70
η	Std. Deviation of innovation to GDP	0,026	0,026
κ	Pricing kernel parameter	0,00	10,00
β	Domestic discount factor	0,77	0,60
ψ	Direct output cost of default	0,89	0,90

For the remaining country-dependent parameters, I use Brazil as a reference. Together with Mexico and Argentina (and more recently Greece and Spain), this emerging market economy, and serial defaulter (Reinhart, Rogoff and Savastano, 2003), is one of the common references in the related literature. It is also one of the first non-advanced economies to adopt an inflation target regime. Besides, Brazil is a representative case of the ongoing change in the currency denomination of external debt. Using the cyclical component of the Brazilian GDP from 1948 to 2014 in, I obtain

[8] In item II of the Appendix B, I show how this simplifies the model solution.

estimates for ρ and η[9]. Given such values, the simulation method proposed by Schimitt-Grohé and Uribe (2009) provides a transition matrix for the endowment.

In the specification with risk-neutral lenders, I start setting $\kappa = 0$. Next, I choose the values of the two remaining parameters (β and ψ) so that the model with FC debt matches two targeted moments for the years from 1970 to 2006. The intention is that the FC artificial economy replicates Brazil during the period with external debt denominated exclusively in foreign currency. Then, I find a solution for the economy issuing LC debt using the parameters determined by the targeting exercise of the FC case. In this manner, there are no targeted statistics for the LC model.

The first targeted moment is the default frequency. I set it to 2.7%, reflecting one default between 1970 and 2006 (Reinhart and Rogoff, 2008). Similar values are used in other studies in this literature, as Aguiar et al (2016) and Arellano (2008). The second targeted value is the average external debt as a share of GDP, 23.4%. In order to reconcile data and model, I do not use this value. In the model, after a default, the economy re-enters markets without debt. However, this full repudiation of liabilities (haircut rate of 100%) does not appear in the data. According to Cruces and Trebesch (2013), the average haircut rate (excluding cases of heavily indebted poor countries) is 29.7%. Therefore, I target an average debt level of only 29.7% of the original statistic, leading to a debt-to-GDP ratio of interest of 7% (23.4×29.7%)[10]. Such procedure delivers $\beta = 0.77$ and $\psi = 0.89$ for the parameters governing the domestic discount factor and the direct output cost of default, respectively[11].

In the specification with risk-averse lenders, the calibration strategy is identical. The only difference is that I target three moments and use three parameters: κ, β, ψ. The targeted debt level is the same as before. The second target is the average spread on FC Brazilian bonds until 2006[12], 7.7% on average, higher than default frequency used in the

[9] The cyclical component is obtained using the HP filter. I do not use GDP data for more recent years because they are computed from quarterly estimates and still subject to revisions. The estimates are close to the ones obtained by Ottonello and Perez (2016) using only the GDP of the tradable sector with data from a panel of emerging countries.
[10] Chatterjee and Eyigungor (2012) use this same calibration approach in a seminal paper of the related literature.
[11] The values are close to those used by other papers in the related literature. For the discount factor, see Nuno and Thomas (2016), Alfaro and Kanczuk (2007) and even the seminal paper of Arellano (2008). For the output cost, see again Arellano (2008), considering that in the current paper only the traded sector suffers from such cost.
[12] Spread data start in 1994, when Brazil regains accesses to international financial markets after a default. See Appendix A.

previous exercise. With risk-averse lenders, the FC spread reflects both the quantity and the price of risk; under risk-neutral pricing, the spread reflects only the quantity of risk, i.e., the default probability. The last target is the share of the FC spread related to the default premium, 38%, according to Longstaff et al (2011)[13]. The values retrieved are $\kappa = 10$, $\beta = 0.60$ and $\psi = 0.90$.

I solve the model numerically using value function iteration in a discrete state space. As suggested by Hatchondo et al (2010), I use a one-loop algorithm that iterates simultaneously on the value and bond price functions. This corresponds to finding the equilibrium as the limit of the equilibrium of the equivalent finite-horizon economy.

4. Quantitative results

4.1. Policy Functions

Figures 2 and 3 present the policy functions for the FC and LC cases, respectively, with the benchmark calibration. In each panel, the lines represent the policy function for different realizations of the endowment. The horizontal axis depicts the current debt level (not the amount borrowed in period t, i.e., the chosen level of debt for the next period).

For the FC economy, default is more likely to happen in bad times (low realizations of the endowment process) and when debt level is elevated (panel A of Figure 2). In panel B we can see that more debt is accumulated in good times. This suggests a pro-cyclical trade balance in the economy, because consumption exceeds output when the latter is higher. Since default probability is lower in good times, interest rates are also reduced (debt prices are higher). Furthermore, Figure 4 displays that the interest rate charged increases with debt levels, because default is more probable when debt is high.

Panel C plots the real exchange rate, and we can see that it depends both on the debt level and the output shock realization. The real exchange rate is lower (appreciated local currency) when output is above its mean, as commonly observed in emerging markets[14]. Notice that the real exchange rate policy function turns into a plateau at the debt level from which default is the optimal choice. To the right of such point, the debt level is not relevant, because the sovereign defaults. Panel D shows that inflation is always zero.

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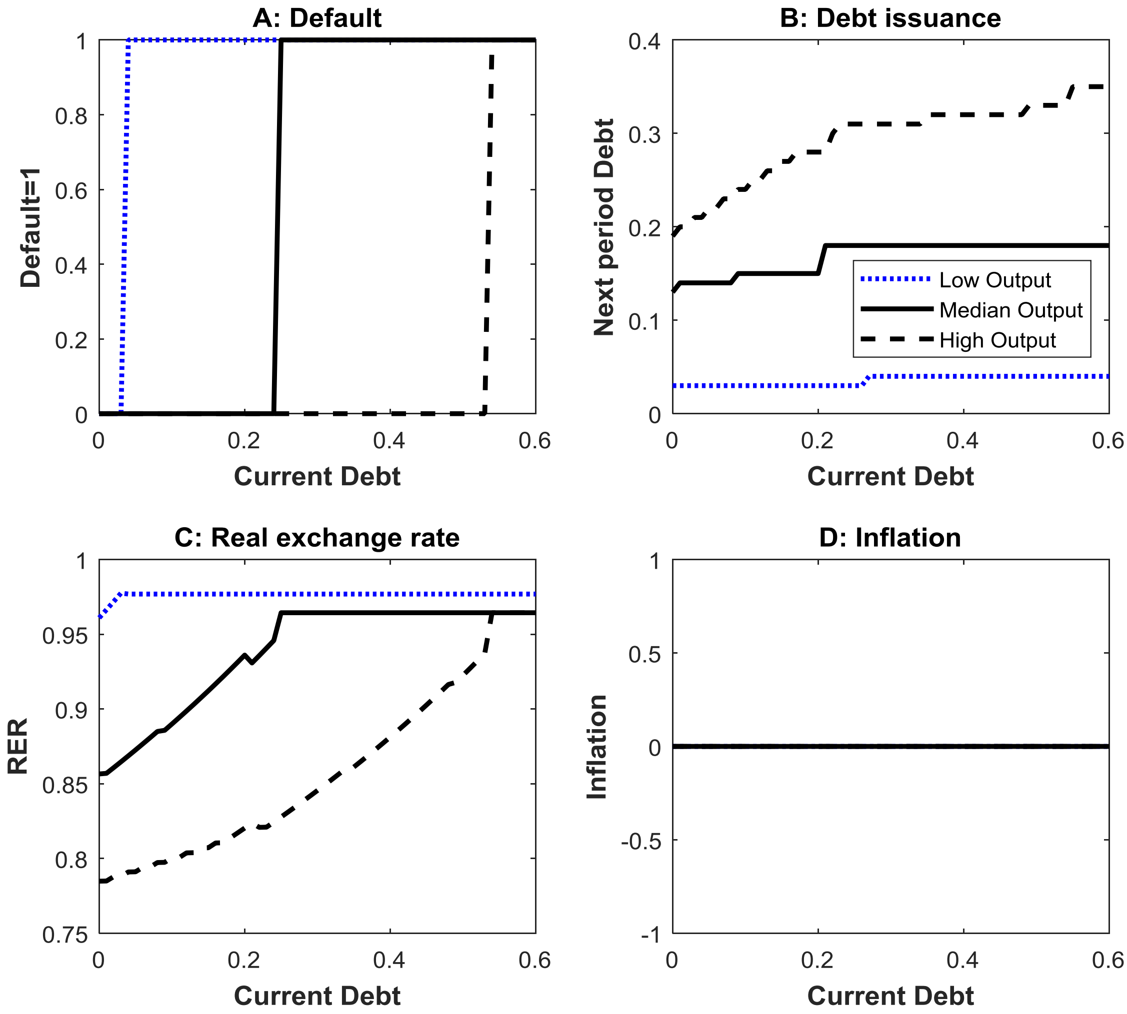
[13] I use the average of the estimates of the fraction of the risk premium to total spread from table 5, excluding Bulgaria, that presents a negative value.

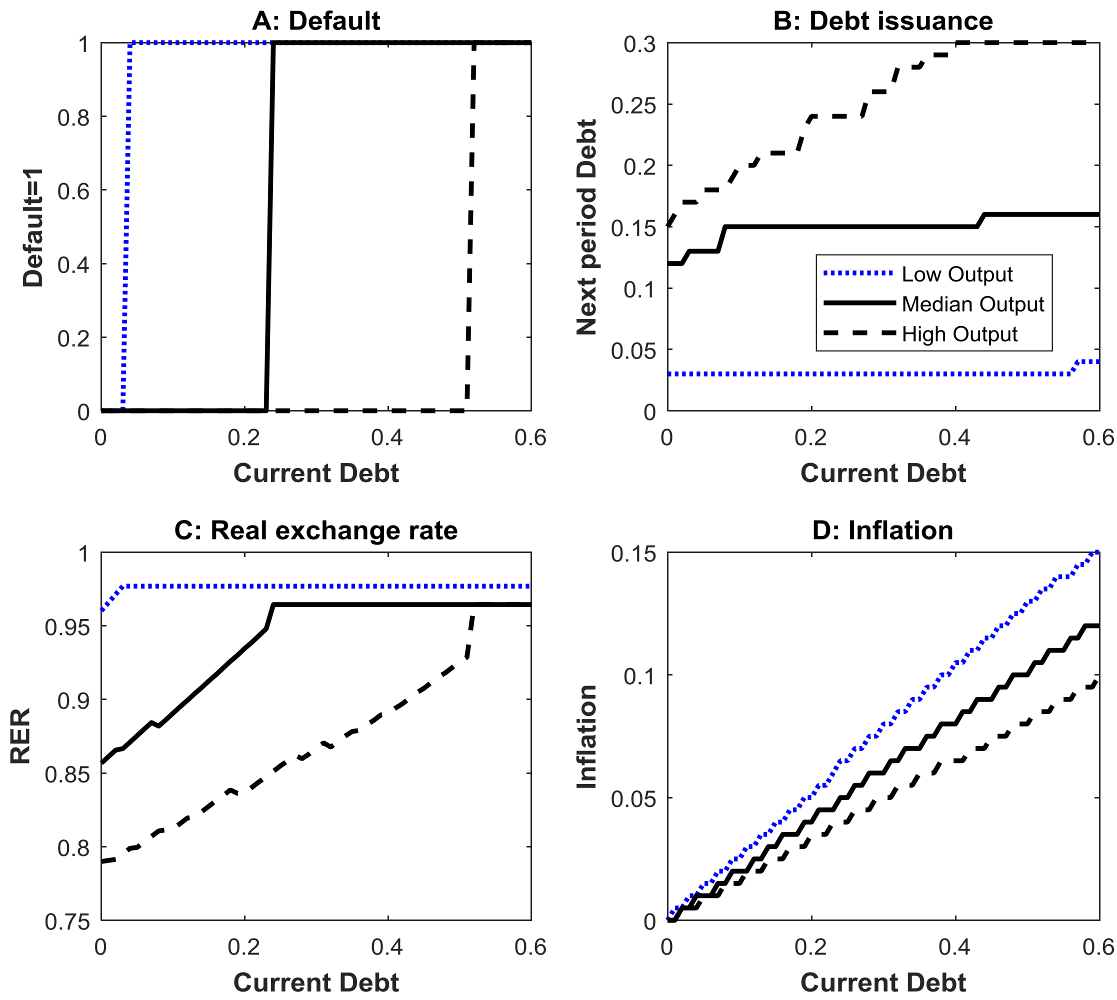
[14] See table 3 in this text and table 4 in Alfaro and Kanczuk (2017).

Figure 2: Policy functions for an economy with FC debt



Note: Each panel in this figure plots the plots a policy function for three different levels of output: the lowest, the median, and the highest. The horizontal axis represents the current debt level at the start of the period. Results are from the benchmark calibration.

Figure 3: Policy functions for an economy with LC deb



Note: Each panel in this figure plots the plots a policy function for three different levels of output: the lowest, the median, and the highest values. The horizontal axis represents the current debt level at the start of the period. Results are from the benchmark calibration.

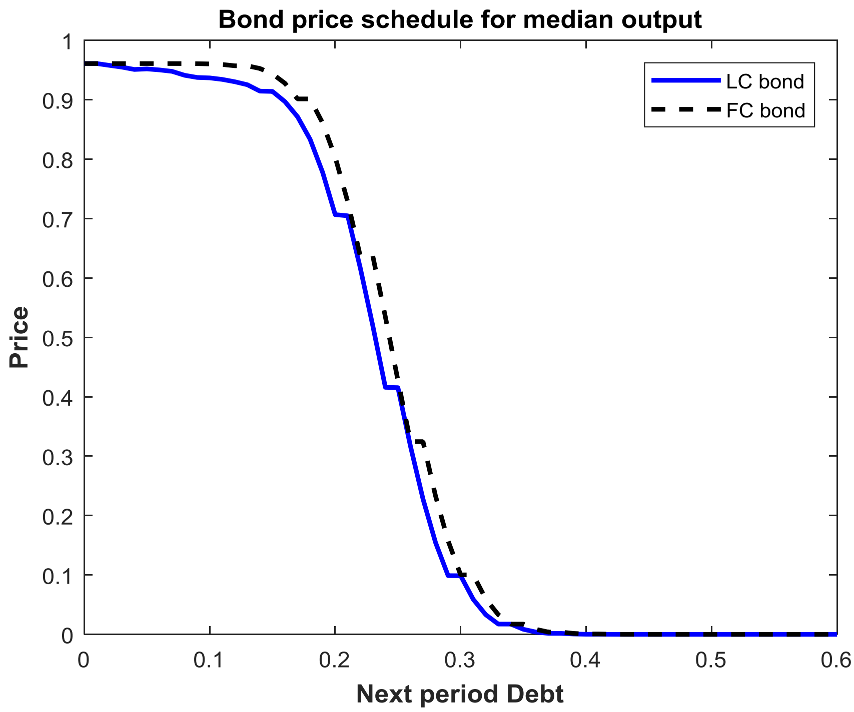
The economy with LC debt (Figure 3) has policy functions similar to those of the FC case, except for inflation. Default is still more likely in when debt is high and output is low; more borrowing takes place during good times; the real exchange rate rises with current debt and diminishes with output. The novelty is the inflation choice (panel D)[15]. As expected, the sovereign has more incentives to inflate when debt is high and, for a fixed quantity of debt, when output is low. Facing adverse shocks, the sovereign raises

[15] When the government defaults, the optimal inflation is zero even with LC debt. For illustrative purposes, panel D in Figure 3 plots the inflation rate that the government chooses if it decides to honor its obligations even when default is the optimal choice.

inflation to free up resources for consumption. The increases in inflation and real exchange rate implies higher nominal exchange rates in moments of low output.

Figure 4 plots the prices of FC and LC debt for the benchmark calibration. The price falls as the amount of debt to be repaid in the next period increases. In the FC economy, this occurs exclusively because the probability of default rises with the amount of debt issued. In the LC economy, the default risk is not the only factor behind the declining debt prices. As debt issuance increases, the expected nominal exchange rate depreciation also moves up. As exhibited in the previous figure, both inflation and real exchange contribute to the expected nominal depreciation.

Figure 4: Price of debt



Note: The figure plots the bond price function for the median level of output. The horizontal axis represents the choice of next period debt. Different lines represent economies issuing debt denominated in different currencies. LC stands for local currency; FC, foreign currency. Results are from the benchmark calibration.

For the specification in Figure 4, the price of LC debt is lower than the FC one, meaning that the total risk of LC debt (default plus exchange rate) is higher. However, as Table 3 in the next subsection shows, the default risk is lower in the LC economy than its equivalent in the FC case. It is possible that, for some parametrizations, the total risk in the LC economy is lower than in the equivalent FC economy. One such case appears in

Table 3. It is the situation for an economy with arbitrarily large utility costs of inflation ($\gamma = +\infty$), in which the sovereign never inflates and defaults less often.

4.2. Simulation and welfare

The first two columns in Table 3 bring data from the Brazilian economy for two different terms. In the first (1971-2006) debt was issued in US dollars, and in the more recent (2006-2017) the role of the local currency has been increasing. The remaining columns present statistics calculated using simulated data from different specifications of the model.

Table 3 - Basic statistics: Data and Model

Variables	Data		Model					
			Benchmark		Risk averse lenders		γ=0.85	γ=∞
	1971-2006	2007-2017	FC debt	LC debt	FC debt	LC debt	LC debt	LC debt
	1	2	3	4	5	6	7	8
	Average							
Default frequency	2.7	--	2.4	1.4	3.4	3.0	1.4	1.8
Debt/GDP	7.0	1.4	7.8	7.5	6.2	6.3	7.3	7.9
Inflation	--	4.3	--	2.9	--	2.4	4.2	0.0
Default Risk Premium	7.7	2.5	2.8	1.5	6.8	5.9	1.4	1.8
Nominal Spread	--	10.2	--	4.7	--	9.4	6.0	--
	Standard deviation							
Trade balance	2.7	1.0	1.5	1.2	1.6	1.4	1.2	1.4
Inflation	--	2.4	--	0.6	--	0.8	0.9	--
Real exchange rate	21.9	10.4	2.3	2.1	2.3	2.2	2.1	2.2
Default Risk Premium	3.0	0.7	1.7	1.0	3.1	3.4	1.0	1.2
Nominal Spread	--	0.7	--	1.0	--	2.8	1.2	--
	Correlation with Output							
Trade balance	-0.5	-0.8	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
Inflation	--	0.3	--	0.5	--	0.5	0.5	--
Real exchange rate	-0.4	-0.7	-0.8	-0.9	-0.8	-0.8	-0.9	-0.8
Default Risk Premium	0.0	-0.7	-0.7	-0.8	-0.7	-0.7	-0.8	-0.8
Nominal Spread	--	0.1	--	0.6	--	-0.4	0.7	--
	Welfare change							
Equivalent consumption	-	-	-	-0.05	-	-0.01	-0.10	0.07

Note: Columns 1 and 2 present statistics calculated with Brazilian data described in Appendix A. Each column from 3 to 8 reports statistics for a different model specification. They are calculated using simulated data for 500 thousand periods excluding those in which the economy is excluded from markets.

Columns 3 and 4 show results for the benchmark calibration with risk neutral debt pricing. In the FC economy (column 3), the simulated average debt and the default frequency match their targeted counterparties. Since the default risk premium (total spread in foreign currency) is directly linked to the default frequency, the model underestimates the average observed spread. The model fails to generate enough variability in the real exchange rate, but produces volatilities in the correct order of magnitude for trade balance and the default risk premium. Correlation with GDP is negative for exchange rate and trade balance, as in the data. These are not characteristics peculiar to the Brazil, but prevail in emerging economies[16]. The counter cyclical trade balance reflects that the sovereign issues more debt in good times, when spreads are lower, increasing even more its consumption[17].

Surprisingly, in Brazilian data, the correlation between the default premium and GDP is close to zero between 1994 and 2006. However, as Figure 5 reveals, this is influenced by an abrupt fall (and possible structural break) in the EMBI+ spread in 2005 and 2006. Excluding these two years, the correlation changes from -0.03 to -0.30. This last value is closer to the seen in the full sample (-0.27 in 1994-2017) and to the stylized fact for emerging markets as a whole. In general, the model with FC debt performs well in explaining the Brazilian experience in the period of US dollar denominated external debt.

Compared to the previous case, the model with LC debt suggests decreases in: i) default frequency (and average default risk premium), ii) average debt, iii) real exchange rate volatility, and iv) mean and standard deviation of both risk premium and trade balance. All of these are in in line with the changes observed between the two periods.

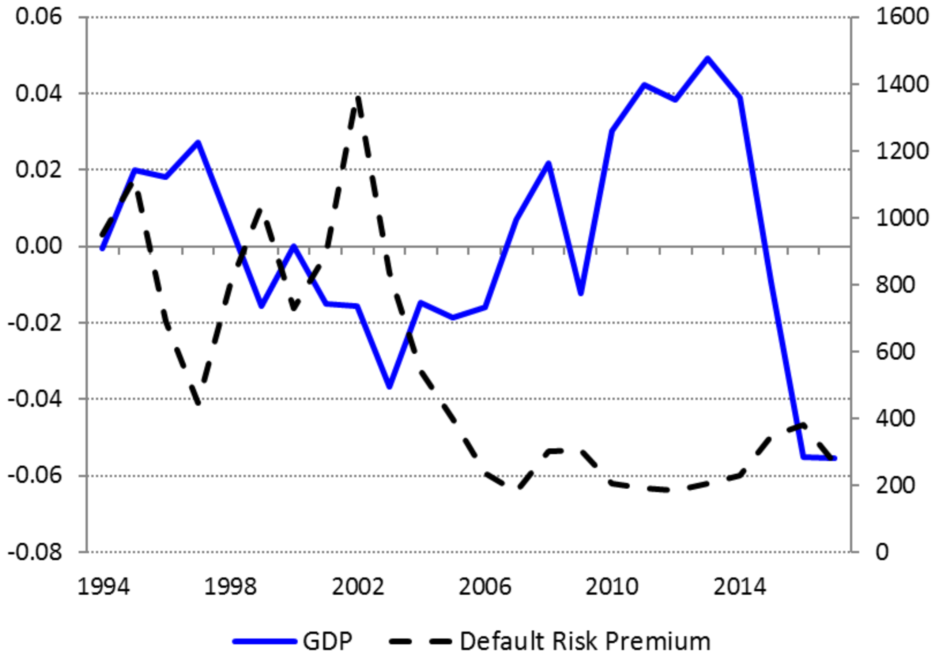
The decline in the default frequency is a consequence of the use of inflation and real exchange rate depreciation during bad times. A reduction in the consumption of traded goods leads to a real depreciation that contributes to a relief of the debt burden. In the FC economy, the decline in the consumption of traded goods also increases the real exchange rate, but does not affect the debt burden. In this sense, I combine the two previously mentioned literatures. In the first, real exchange rate plays a role but monetary policy is muted (Gumus, 2013, Asonuma, 2016, and Alfaro and Kanczuk, 2017). In the

[16] Alfaro and Kanczuk (2017), and Uribe and Schimitt-Grohe (2017), respectively.

[17]In this model debt accumulation and trade balance are directly associated. As usual in this literature, I compare the model and the data looking at the debt for averages and at trade balance for variances and correlations.

second one, monetary policy is discretionary, but there is no exchange rate effect because there is only a single traded good (Nuno and Thomas, 2016, Onder and Sunel, 2016, Du and Schreger, 2017, among others).

Figure 5: GDP (LHS) and Default Risk Premium (RHS)



Note: GDP refers to the cyclical component of the log of GDP obtained with the HP filter. Default Risk premium is the Emerging Markets Bond Index Plus (EMBI+) for Brazil.

Although it is not a targeted variable, the model generates average inflation of 2.9%. Such amount represents a significant share of the average inflation in the period (4.3%). This suggests the relevance of the proposed mechanism – ability to use inflation to erode debt – in the inflationary bias of emerging markets[18].

In column 2, the debt-to-GDP ratio is the average LC external debt (4.7%) multiplied by the typical haircut rate (29.7%). Although the model points to a reduction in the average debt level, we observe a more pronounced fall in the data. One possible explanation for this difference, as exposed by Alfaro and Kanczuk (2017), is that Brazil is still transitioning between the two regimes. The trend in LC external debt as a share of GDP in Figure 1 supports this view. An alternative interpretation is that the domestic

[18] Onder and Sunel (2016) find similar a result in a quantitative model of default with a single traded good calibrated for Spain.

impatience decreased since 2006. In the model, this is a raise in the domestic discount factor (β). In the literature of quantitative models of sovereign default, this parameter is calibrated with values lower than those used in the business cycles studies. The customary interpretation is that this might reflect political myopia. Bianchi, Hatchondo and Martinez (2018) use this decrease in political myopia, in a model of debt and default, as an explanation for the accumulation of international reserves in emerging markets. Here, such a reduction in the domestic impatience/political myopia may also serve as a cause of lower debt levels.

In the LC economy, the default risk premium is the spread that would be paid in the absence of the nominal exchange risk. Therefore, it is the spread on the foreign currency debt assuming that the government defaults jointly on all its liabilities. It falls from the FC to the LC case, as it did in the Brazilian economy between the two periods analyzed. However, the default risk premium is lower in the model than in the data. The nominal spread (includes default and exchange rate risk) is also lower than the empirical counterpart. The model performance in this criteria improves with the inclusion of risk-averse lenders.

The model replicates well volatilities for trade balance, default risk premium and nominal spread, but explains only part of the inflation variability. It is still unable to generate the correct amount of real exchange rate volatility. However, this statistic falls from the FC to the LC case, as noticed in the data. In model terms, this reduction in real exchange rate volatility maps exactly in consumption volatility.

Correlation with GDP has the right sign for all variables. As in Brazil from 2007 to 2017, the model exhibits counter-cyclical behavior for default risk premium, trade balance, and real exchange rate, and pro-cyclical for inflation[19]. The policy function shows that the sovereign inflates more in bad times for a given debt level. Nevertheless, the pro-cyclical inflation appears because, during periods of high output, the sovereign accumulates more debt and, thus, is more tempted to use inflation. As a consequence, the model creates pro-cyclical nominal spreads. Even if in the data this correlation is only slightly positive, clearly it is different from the categorical negative association between output and default risk premium.

[19] Ottonello and Perez (2016) and Onder and Sunel (2016) also document the positive correlation between inflation and GDP for a sample of emerging countries and for Spain, respectively.

To assess welfare gains from changing the denomination of debt, I calculate the flow certainty equivalent consumption for models in columns 3 and 4 using the same procedure as Chatterjee and Eyingungor (2012). I find the value of c that solves equation (23) below, in which $\Pi(y^T)$ is the invariant distribution of the Markov chain for y^T.

$$\frac{c^{1-\sigma}}{(1-\beta)(1-\sigma)} = \sum_y v(y^T, 0)\Pi(y^T) \tag{23}$$

The benefits of the LC case are fewer defaults and less volatility in the real exchange rate (and consumption, consequently). The costs are the lower debt sustainability and the positive level of inflation, which affects utility directly. All considered, I find that a change from the FC to the LC regime leads to a welfare loss equivalent to 0.05% decrease in consumption.

Other papers have assessed the welfare consequence from such change in the currency denomination using quantitative models of default. Each model is calibrated to a different situation, so comparisons must be made with this caveat in mind. Gumus (2013) finds gains of 0.02% in equivalent consumption in a model with two sectors and no discretionary inflation. In an environment with a single traded good and with discretionary monetary policy, Nuno and Thomas (2016) arrive at losses of 0.3%. Their results remain in this range for a wide set of robustness exercises. They only find gains from nominal debt if the output growth volatility is 20%, much higher than 3.2% in their benchmark calibration. Onder and Sunel (2016), also in a setting with only one good and discretionary inflation, find losses of up to 1% in their benchmark calibration. This happens as a consequence of inflation increasing from zero to 2.5% and of debt-to-GDP ratio falling by half. The welfare losses reduce to less than 0.10% if the parameter governing inflations costs is changed, so that average inflation is 0.4% and debt-to-GDP ratio falls only 10%. They also find welfare gains, less than 0.2%, if the variance of the exogenous shock of output process increases from 1% to 3.5%.

The first robustness exercise is the inclusion of risk-averse lenders (columns 5 and 6). This modification allows the model with FC debt to replicate the average default premium seen in the data, while maintaining the other relevant results. The insertion of this feature in the model with LC debt also brings few modifications. The main advantage is that the model mimics the average nominal spread, but this variable becomes counter-cyclical, in opposition to the data. Compared to the FC case, the model with LC debt still indicates reductions in: i) default frequency (and average default risk premium), ii) real exchange rate volatility, and iii) mean and standard deviation of both risk premium and trade balance. However, now the average debt remains constant. Overall, the welfare loss reduces from 0.05% to 0.01%.

Column 7 brings another robustness check. It consists of the use of a lower utility cost of inflation, what can be interpreted as a decrease in the credibility of monetary policy (Onder and Sunel, 2016, Ottonello and Perez, 2016, Du, Pflueger and Schreger, 2017). I set $\gamma = 0.85$, instead of 1.3, making the model's average inflation match its observed counterparty (4.2%). I keep the same value of the benchmark calibration for the other parameters in the model. Volatilities and correlations with output do not change in a meaningful manner. Comparing with the model in column 2 (the parameter γ does not influence the FC economy), the decline in the mean debt is greater than in the benchmark scenario. This suggests that lower inflation credibility might be a reason why the observed average debt level in Brazil is lower than suggested by the benchmark LC model. All things considered, the welfare loss from changing from FC to LC is larger with the lower credibility of monetary policy, 0.10% instead of 0.05%, in line with Nuno and Thomas (2016) and Onder and Sunel, (2016) in models without real exchange rate movements.

The opposite case, present in column 8, is when the monetary policy is fully credible and can commit to zero inflation ($\gamma = +\infty$). Then, only the real exchange rate relieves the debt burden during bad times. Default frequency declines to 1.8% (column 3), lower than under FC debt, but higher than when the use of inflation is possible (column 4). In the absence of inflation risk, debt sustainability increases in comparison to the FC case. The general effect is a welfare gain from issuing LC debt of 0.07% of the certainty equivalent consumption, in accordance with Gumus (2013). This type of analysis is not possible in the framework with a single traded good, because, in such setting, foreign currency and local currency are exactly the same if inflation is always zero.

5. Conclusion

This paper develops a quantitative model of external debt and sovereign default extended to incorporate real exchange rates and discretionary inflation. I use it to investigate the consequences for emerging countries of borrowing from foreigners in domestic currency. The model replicates relevant features of the Brazilian economy since 2007, when external debt denominated in local currency started to become relevant. Both in the data and in the model, default risk premium, trade balance, and real exchange rate are counter-cyclical variables, while inflation is pro-cyclical. This last feature, similar to a Phillips curve, occurs because during periods of high output the sovereign accumulates more debt and is more tempted to use inflation.

Results suggest that altering the currency denomination of external debt from foreign to local currency has modest welfare implications. In the case of discretionary monetary policy, issuing LC debt entails welfare losses; the higher the degree of discretion, the greater the losses. The negative effects of issuing debt in domestic currency originate from higher inflation and lower levels of sustainable debt. Nevertheless, if the policy maker can commit to price stability, the economy has welfare gains from switching to nominal debt. In this scenario, the depreciation of the real exchange rate relieves the debt burden during bad times. Regardless of the credibility of the monetary policy, however, the frequency of explicit defaults invariably falls.

Such relation between monetary policy credibility and the welfare consequences from the currency denomination of external debt presents an alternative explanation for the "original sin". If the monetary policy credibility is very low (as high inflation in emerging markets before they adhered to reliable monetary policy regimes suggest), issuing LC debt might lead to meaningful welfare losses. Hence, denominating debt in FC is a choice, and not necessarily a consequence of the inability to issue LC debt for foreign investors due to an incompleteness in international financial markets.

The current analysis might be of interest not only for emerging economies that are gaining capacity to borrow from abroad in domestic currency, but also for countries in the periphery of the Euro Area. By joining the monetary union, these countries borrow only in Euros and, therefore, renounce the ability to inflate the debt away.

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6. Appendix A – Data

Figure 1. Net foreign currency debt comes from the Central Bank of Brazil Time Series Management System (code 11420). I use it due to its long sample, since 1970. Although it includes debt issued abroad in any currency (including the Brazilian Real), it does not include debt issued in Brazil and held by nonresidents. Since 2004 it is possible to check the share of local currency denominated debt in this variable. I find that it is, on average, less than 2% for the period 2004-2006, when this variable is used. Net local currency debt is the amount of fixed income bonds issued in the domestic market held by nonresidents (code 22160 in the Central Bank of Brazil Time Series Management System), available since 2001. It comprises mostly foreign holdings of domestically issued central government debt. I consider that the gross amount of this type of debt equal its net amount, since I assume that debt type assets held abroad by Brazilians are always

denominated in foreign currency. More details about this assumption are present in this appendix in the discussion about Table 1.

Table 1. It lists 12 emerging countries whose gross external debt (excluding intercompany lending operations, classified as direct investment) exceeds US$ 50 billion in 2015 and for which its currency composition is available. Together they amount to US$ 2.7 trillion in debt liabilities. Debt data by currency come from the Quarterly External Debt Statistics Database (QEDS), a collaboration between the World Bank and the IMF. This information is available only for countries that subscribe to the IMF's Special Data Dissemination Standard. Currency composition comes from Table 2 in "Country Tables" and Table C5 in "Cross Country Tables". I compare the latter data with those in Table C2 in "Cross Country Tables" to check for which countries the gross external debt statistics contains intercompany lending, which I classify as Direct Investment instead of Debt. I also i) compare the data to the sovereign investor base estimates of Arslanalp and Tsuda (2014), and ii) check the Metadata by country, to exclude countries whose statistics available at QEDS do not include non-residents participation in domestic bond markets.

In order to construct net external debt measures by currency, it is necessary to subtract assets held by the emerging markets. I restrict the analysis to assets classified as debt instruments or international reserves, both obtained from the IMF Balance of Payments and International Investment Position Statistics. Since there is not information available by currency denomination for such assets, I suppose that all of them are denominated in foreign currency. Fortunately, data available for Brazil suggest that this a sensible assumption for an emerging market. Using data from the Central Bank of Brazil, I find that in 2015 only 0.2% of debt-type assets and reserves were denominated in Brazilian Real. See tables 4 and 33 in the monthly Press Release for the External Sector Statistics, available at http://www.bcb.gov.br/ingles/notecon1-i.asp. Since the totality of international reserves is denominated in foreign currency, I obtain the estimate using assets by currency denomination (excluding intercompany lending) from table 33

Table 3.

Output: Brazilian GDP data since 1947 obtained from the System of National Accounts calculated by IBGE, the Brazilian national statistical office. For the most recent years, the information comes from the Quarterly National Accounts. I use the Hodrick-Prescott filter to recover the cyclical component of the logarithm of the GDP. This information is used to calculate the correlations with output.

Foreign and local currency net external debt: see the details in Figure 1.

Inflation: Difference between inflation rates of Brazil and USA. For Brazil I use the IPCA (broad consumer price index), calculated by IBGE. This is the reference rate for the Brazilian inflation target regime. For the USA I use the 'Consumer Price Index for All Urban Consumers: All Items' from the BLS.

Real exchange rate: Trade-weighted real exchange rate using CPI inflation. It is obtained in the Central Bank of Brazil Time Series Management System (code SGS BCB 11752). The sample starts in 1988.

Trade balance: Trade balance as a share of the GDP. Data come from the Central Bank of Brazil Time Series Management System (codes 23467 and 2302). The more recent time series using the methodology of the 6th edition of the Balance of Payments and International Investment Position Manual starts in 1995. For previous years, I use the information calculated using the guidance of the 5th edition of the Manual. The GDP data in dollars comes from the same source (code 7324). The final variable is available since 1962.

Default risk premium: Emerging Markets Bond Index Plus (EMBI+) for Brazil. Available since 1994. It measures the default risk for sovereign foreign currency bonds issued abroad and is available since 1994. Even for the period 2007-2016, I choose to use this variable, since it is a direct measure of credit risk exclusively. Du and Schreger (2016) compute local currency default risk for 10 emerging countries between 2004 and 2015 and find an average value of 1.45%, close to its equivalent in foreign currency, 2.01%. Although I model the total amount of external debt, I use government debt spreads due to data availability and its high correlation with corporate debt spreads, as pointed by Durbin and Ng (2005).

Nominal spread: Difference between local currency government bond interest rates in Brazil and USA. For Brazil, I use the interest rates on the NTN-F bond. This is a fixed-rate nominal bond, as the debt in the model. It is also the preferred bond of foreign investors. In December 2017, this type of bond represented 89% of the holdings of foreign investor in the Brazilian government debt market. Brazilian data comes from the Monthly Debt Report produced by the Brazilian National Treasury, Ministry of Finance (table 4.1). The USA interest rate is the 5-Year Treasury Constant Maturity Rate.

7. Appendix B – Model

I. Relation between q_t and $\tilde{q}_t$.

Starting from equations (13) and (5), one can obtain (B1) and, subsequently, (B2). The latter shows that $\tilde{q}$ does not depend on the current state of the economy.

$$q_t = P_t \alpha \left(\frac{c_t^T}{c_t^N}\right)^{\alpha-1} \boldsymbol{E_y}[m_{t+1}(1-f_{t+1})\frac{1}{\alpha}\frac{1}{P_{t+1}}\left(\frac{c_{t+1}^T}{c_{t+1}^N}\right)^{1-\alpha}] \quad \text{(B1)}$$

$$q_t = \alpha \left(\frac{c_t^T}{c_t^N}\right)^{\alpha-1} \boldsymbol{E_y}\left[m_{t+1}(1-f_{t+1})\frac{1}{\alpha}\frac{1}{\pi_{t+1}}\left(\frac{c_{t+1}^T}{c_{t+1}^N}\right)^{1-\alpha}\right] = \epsilon_t \tilde{q}_t \quad \text{(B2)}$$

II. Solution for the resource constraint in the LC case

Resource constraint (19) can be re-written as (B3). Given the other parameters and variables, this is a non-linear equation in c_t^T. Joining all variables and parameters except c_t^T in constants A and B, we have equation (B4). In the empirically relevant case with $\alpha = 0.5$, there is a closed form solution, (B5), used in the numerical problem (one root is discarded because it leads to a negative association between consumption and inflation).

$$c_t^T = y_t^T + \tilde{q}_t \hat{d}_{t+1} - \frac{1}{\alpha}\left(\frac{c_t^T}{c_t^N}\right)^{1-\alpha} \frac{\hat{d}_t}{\pi_t} \quad \text{(B3)}$$

$$c_t^T = A - B(c_t^T)^{1-\alpha} \quad \text{(B4)}$$

$$c_t^T = \frac{\left(-\sqrt{B^2+4A}-B\right)^2}{4} \quad \text{(B5)}$$